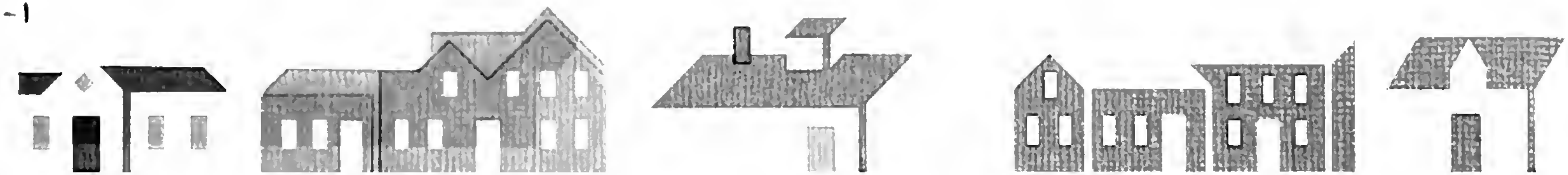

WARM PLACES

A sampling of energy-efficient Montana homes

free from DNRC

WARM PLACES

A sampling of energy-efficient Montana homes

Montana Department of Natural Resources & Conservation
1520 East Sixth Avenue DNRC Helena, MT 59620-2301

Spring 1988

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Introduction

A Smart New Breed

The purpose of *Warm Places* is to persuade prospective home builders that the house they always wanted can also be energy efficient without sacrificing desirable features. It is not necessary for an energy-efficient house to look like a box with tiny windows. A portfolio of plans, ideas, photographs, illustrations, and interviews with home owners demonstrates a new breed of house construction that Montanans are choosing for comfort and energy savings in our extreme climate.

Although all the houses in this book were built with energy efficiency in mind, not all are built and operated to save every possible nickel. The amount of saving depends on what energy conservation measures are built into the house, the living patterns of the occupants, and the amount of effort the house occupants expend in activities such as setting thermostats back at night. A house that is kept at 75 degrees 24 hours a day will have higher than average utility bills, for example. The indoor temperatures favored by the home owners in this book range from 62 to 80 degrees, with heating bills that vary accordingly.

Galloping Technology

The technology of building for energy efficiency has changed rapidly in the past 10 years. All the houses in this book were built in this time period, and they reflect the changes in technology and approach. For instance, in the late seventies, earth-sheltered and envelope houses were popular. Since that time, builders have found simpler, less costly ways to achieve similar degrees of comfort and energy savings.

Even the best, most efficient houses could be improved by lessons learned in their construction and operation. Given the dynamic nature of energy-efficient housing, the reader may wonder what the future holds.

Insulation and More

When properly installed, insulation, caulking, multi-pane windows, insulated exterior doors, and an air-vapor barrier are some of the best investments available when building a new house. But how much insulation is enough? That depends primarily on the construction budget, locality, and fuel choice. The table below lists generally accepted insulation ranges for energy-efficient houses in Montana.

Natural gas currently is less expensive than electricity, so heating with gas may cost less than heating a similar house with electricity. The higher insulation achieved through double-wall construction probably would be cost-effective for electrically heated houses, depending on the location.

Recommended Insulation Values for Houses

	Minimum	Superinsulated
Below-slab	R10 (2 feet around perimeter)	R10 (2 feet around perimeter)
Basement Walls	R19	R19
Above-grade Walls	R26	R40
Ceilings	R49	R60
Windows	Double glazed with Low-E film	Double glazed with Low-E film
Doors	Foam Core	Foam Core

Air-vapor Barrier

Insulation reduces conductive heat loss. It takes an air-vapor barrier to slow heat loss from air leaks. This barrier can be a polyethylene membrane installed in walls and ceiling, an air-tight layer of urethane insulation, gasketing and caulking behind drywall in combination with a moisture-impermeable paint, or polyisocyanurate foam board insulation with edges taped and caulked.

In heavily insulated houses, the air-vapor barrier must be continuous if it is to do its job. That is, the barrier must enclose the walls and ceiling of the living space, and the openings around electrical plug-ins, light fixtures, plumbing stacks, and so forth, must be sealed. If the air-vapor barrier isn't continuous, positive air pressure (greater air pressure inside the house than outside) pushes air, which always carries some water vapor with it, into the walls or ceiling. In heavily insulated houses, the water vapor will condense and can cause moisture problems in the walls or ceiling before it makes its way to the exterior of the house.

Controlled Ventilation

Tightly-built houses require a ventilation system because they have no air leaks to bring outside air into the house or carry stale inside air out. Over the past 10 years, heat recovery ventilation (HRV) systems have become common. Early models of this device sometimes had various problems, but the new models are vastly improved and normally operate trouble-free.

Other ventilation options also are being installed in Montana. One system uses fans in kitchens, bathrooms, and other rooms to exhaust stale air, and a specially designed wall inlet to draw in outside air. A system such as this does not recover heat from the warm exhaust air, but is somewhat cheaper to install than the average HRV system.

Leaving out the ceiling air-vapor barrier so the house can "breathe" is a common but unreliable method for improving ventilation, and can create moisture problems in the ceiling or attic. If ceiling insulation is R38 or less and the house has *good* attic ventilation, the water vapor in

the air escaping into the attic usually will be carried up and out of the house. With thick insulation, however, the water vapor will reach the dew point (see Glossary) and condense while traveling through the insulation. When the temperature is below freezing, the condensed water turns to frost. When the frost thaws, water drips back through the insulation, often collecting in light fixture bowls and staining the ceiling around cutouts.

Winter is especially conducive to moisture problems in tight houses without adequate ventilation. Houses are closed against the cold, which doesn't let moisture out through doors and windows; the attic is cold so no evaporation occurs.

Enclosing the entire living space with a continuous air-vapor barrier and installing a controlled ventilation system is the only sure-fire method for preventing condensation problems in tight, highly insulated houses.

Passive Solar Gain

Passive solar gain can be readily incorporated into just about any house, and will be worth the effort, especially in the sunny portions of the state east of the Continental Divide. Among passive solar facilities, large windows on the south side of the house are the most common. Ideally, they should be equipped with thermal curtains to prevent heat loss at night or on sunless days. Greenhouses and other solar spaces can be either big heat gainers or big heat losers, depending on how they are built, located, and operated. Generally, such facilities should be equipped with curtains or other shading equipment, and should be well ventilated to prevent overheating. Concrete or heavy masonry that can store solar heat inside the house usually are necessary to make sunspaces and greenhouses gain more heat than they lose over the course of a year.

Heating Systems

Zoned heating systems provide heat only where it's needed and at the appropriate temperature for that portion of the living space. Baseboard heaters, radiant floor heating systems, and ceiling panels all provide zoned heat control. Radiant floor systems usually use gas-fired hot water systems. Baseboard heaters can be electric, or gas- or oil-fired hot water. Ceiling panels are electric.

It is critical that the under side of heated slabs be insulated with at least 2 inches of extruded polystyrene, and a thermal break be installed between slab and foundation walls. Poorly insulated heated slabs can lose a tremendous amount of heat to the ground, especially if groundwater is within 10 feet.

For forced-air heating systems, it can pay to install one of the oil or gas furnaces that promise an efficiency of 80 percent and greater. A new publication from DNRC, *Gas Furnaces and Appliances—Sorting Through the Options*, describes the new gas heating systems.

Log Houses

Many Montanans dream of living in a country log house. While this may be appealing to many, it's not the most energy-efficient choice because traditional log walls are notorious energy wasters unless extraordinary measures are taken. Wood has an R-value of just 1.25 per inch, compared to 3.5 per inch for fiberglass batts. Chinking eventually loosens as logs expand, contract, and crack, allowing drafts and heat loss. In spite of these drawbacks, the lure of log houses is strong for many people. We have included two log houses and the methods used to compensate for the log walls.

RSDP/RCDP Funding

The energy efficient innovations in 20 of the houses in this book were partially funded by the Bonneville Power Administration. These houses were built to conform to the energy-efficient construction standards of the Residential Standards Demonstration Program and the Residential Construction Demonstration Project. These two programs are described in the Glossary. The remaining 57 houses in the book received no government energy funding.

Features That Fit

Energy-efficient houses come in many different types. *Warm Places* is a beginning for prospective home buyers or builders who want to know what housing innovations are available and appropriate for their situation. The owners of each house in this book tell what it's like to live in that house, what has worked for them, and what hasn't. Rather than duplicating any particular house, most home owners or builders probably will want to pick and choose various features and combine them as their particular needs require.

The home owners place varying degrees of importance of payback in energy savings features. Some ignore the cost of features because they want the benefit. Others have carefully calculated the return on fuel savings for the investment in construction. Where possible, we've given the payback figure on certain energy features. On the whole, building an energy-efficient house will cost from 2 to 5 percent more than a conventional house. Almost always, the fuel savings (at today's rates) over a period of five to ten years will be greater than the extra cost.

In This Book

The houses are arranged in alphabetical order of towns where they are located. All floor plans have been rendered at the scale of 1 inch equals 16 feet. A Glossary explains building terms used in the articles.

More Information

While the Glossary gives some insight into building terms and techniques, some people will want more detailed information. An inventory of pertinent books from DNRC and others is listed in the bibliography at the end of this book. Utility companies can recommend building techniques and workshops. Designers and builders familiar with energy-efficient construction techniques can provide advice. □

Acknowledgments

Without the cooperation of the home owners who so graciously shared their ideas and feelings and opened their houses to us, this book would not have been possible. We also thank the designers and builders who gave their time to review the articles and to bundle up their blueprints and send them to us.

We are grateful to Capital High School in Helena for lending us their AutoCAD software from which the floor plans were rendered, and to Gary Duff at Capital High for instructing us in the use of the system.

We thank Melanie Matson, a University of Montana graduate student in journalism who contributed her editing skills to the project.

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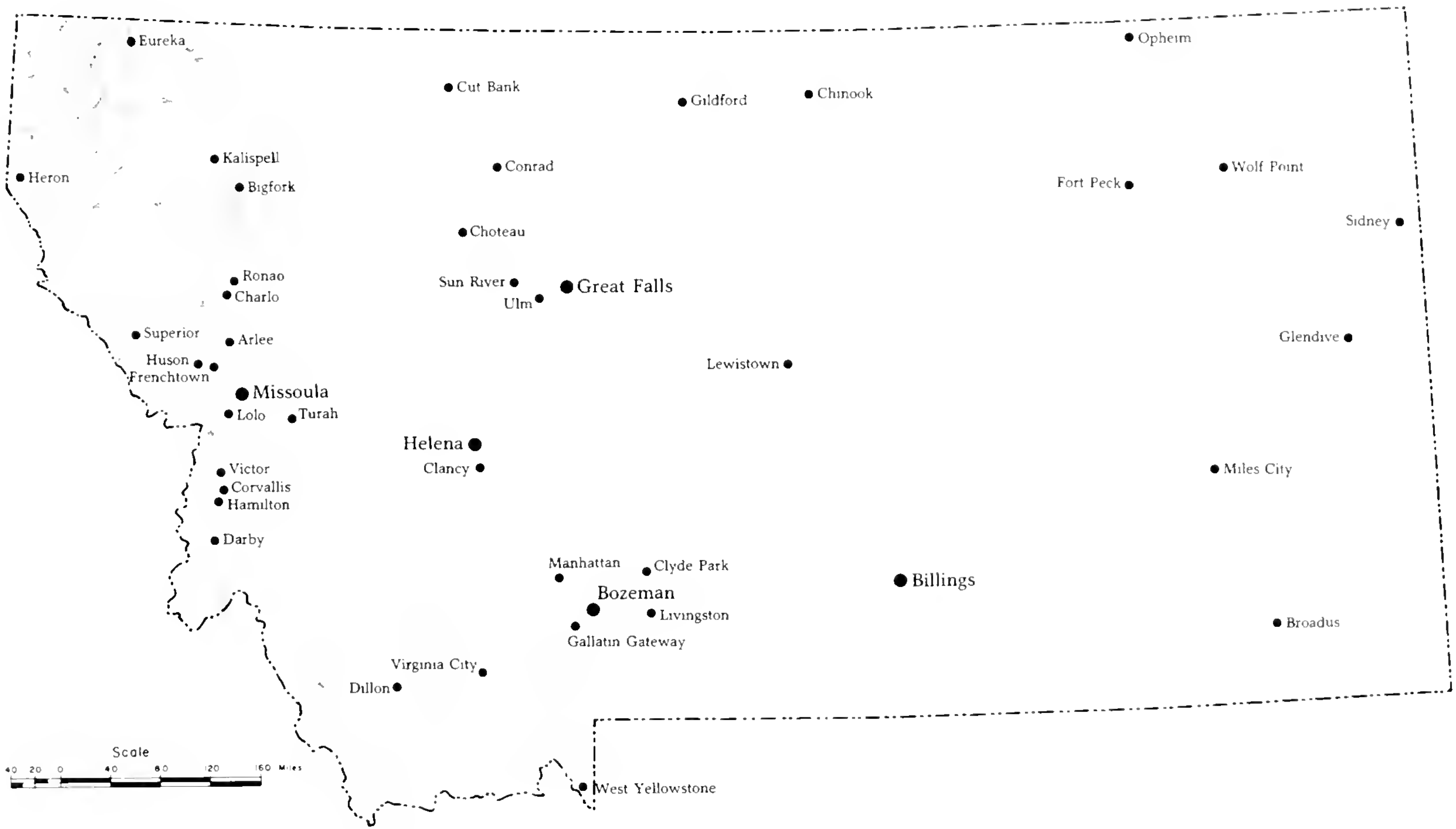
No Endorsements or Responsibility for Errors

Where the Warm Places Are



Different Ideas

Architects are always full of ideas for other peoples' houses, but what does the architect live in? The Arlee house of Missoula-based architect Jay Kirby provides one intriguing answer to this question. Though not complete as of this writing, Kirby's irregular polygonal 22-sided earth sheltered post-and-beam house with geodesic dome cupola clearly is an example of free-thinking design. The house is roughly circular, with an average diameter of about 46 feet. The living area is all on the main floor except for a small work space elevated in the geodesic cupola.

The south side of Jay Kirby's house. Note Trombe wall inside center glass panel.

The Montana Vernacular

Despite the seeming oddity of this house at first glance, there is much that is familiar to Montanans. Massive log ceiling beams, dirt roof, and fireplace all hark back to the functional buildings that pioneering miners and ranchers fashioned from materials at hand. The house is one example of what Kirby refers to as the "Montana vernacular" style of building: the use of traditional, nostalgic building elements in modern forms.

Building With Concrete Panels

Kirby built most of his outer wall with 4-inch-thick concrete panels. These panels were made by pouring concrete into forms lying flat around the perimeter of the floor slab. Before pouring the concrete, Kirby placed 2-inch sheets of expanded polystyrene into the forms as insulation for the interior side of the walls. He later added an inch of polyisocyanurate over the polystyrene.

Immediately after the concrete was poured into the forms, flat rocks were seated into the wet surface to give a rock look to the outside of the exterior walls.

After the concrete was hardened, a farm tractor with a hydraulic hoist was used to tip the panels outward into place. Once all the panels were erect and in place, a cable was tightened around the outside as a permanent tension band. The 18-inch-diameter log roof beams were then hoisted into place with Jay's International Scout and a boom pole.

Holding Up the Roof

Inside the structure, the ends of some of the log beams are supported by a curved, 4-inch-thick concrete wall. This wall was built with several sequential pours of concrete into slip forms that were raised and reset after each pour hardened. Other logs are supported by log posts.

Various Forms of Insulation

Most concrete sections of the outer wall are sheltered by the earth berm. Bedrooms are located on the upwind side of the house, and closets in the bedrooms are built along the outside wall to further insulate the living space.

Owner
Jay Kirby

Location
Arlee

Designer
Jay Kirby

Builder
Jay Kirby, Architect
2011 South Fourth West
Missoula, MT 59801
549-9941

Style
Post-and-beam
22-sided Polygonal
Upper Level Geodesic Dome

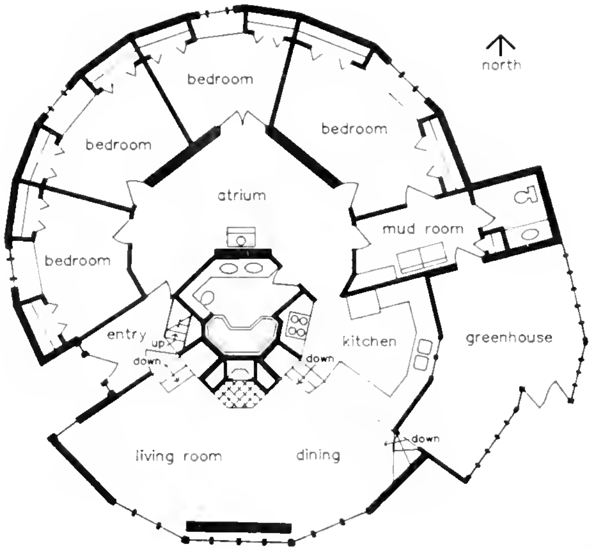
Insulation
Roof - R40
Frame Walls - R25
Concrete Walls - R17
Slab - R10

Square Feet
Main - 1,700

Special Features
Trombe Wall
Earth Sheltering
Polygonal Shape
Internal Stone Walls
Rock-bed Heat Storage
Holding Tank
Unconventional Fireplace Design
Greenhouse

Heat
Passive Solar, Electric, Fireplace

Completed
Projected for early 1988



A Hard-working Fireplace

The Kirby house is designed to be heated primarily by the sun, but when additional heat is needed, a massive native stone wood-burning fireplace is ready for the chore. Two fans draw air into vents in the fireplace masonry near the ceiling and pull it downward along the flue. As it moves down, the air is warmed in part by short sections of rebar placed horizontally in the cavity along the flue, with one end touching the flue. Heat from the flue warms these rods, which then warm the air. The air is further warmed by passing through the space between the masonry and the metal fireplace form. This warm air is discharged through one or more of three outlets near floor level. An operable grill on each of these outlets makes it possible to direct the warm air to where it is needed. Two of the outlets discharge heated air directly into the living space. The third pushes air into a plenum under the concrete floor where rocks from 1 inch to 4 inches diameter absorb heat which can later be retrieved by air moving through the plenum. Air from the plenum is discharged through a floor vent into the narrow air space between the Trombe wall and the exterior wall glass. On sunny days, warm air entering this space can be further heated by the sunlight coming through the window and shining on the massive wall. Jay said he intends eventually to add two active solar collectors to enhance the

Frame portions of the outer wall are insulated with R19 fiberglass batts. Impregnated sheathing and cedar shakes give the frame walls a total R-value of about 25. The floor is insulated with 2 inches of extruded polystyrene between the underlying 6 inches of gravel and the 4-inch concrete slab.

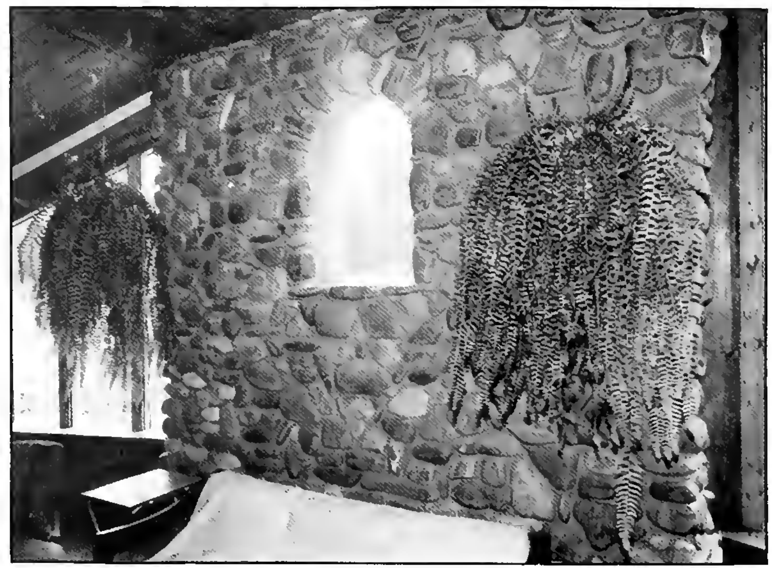
Dirt on the Roof

The roof support structure consists of 2 x 6 tongue-and-groove decking over the log beams, with rough-sawn planks over the decking for additional strength. Toward the apex where the span between beams decreases, 2 1/2-inch rough planks were used. Farther out where span between the beams is greater, 3 1/2-inch planks were laid down.

Four inches of urethane was foamed in place over the rough planks. For waterproofing, two layers of painted-on polyurethane membrane were applied over the foam. Two inches of gravel were placed over the polyurethane for drainage, and 10 to 12 inches of topsoil was laid on top to complete the roof. Jay said the total R-value of the roof is about 40.

Plenty of Windows

The extensive glazing on the south side is double pane, with triple pane glass in the smaller windows on the north side. Low-E glass was not available when the windows were installed, Jay said, but will be used to replace the temporary glazing in the dome. An obvious adjunct to the south glazing is a 10-foot-long concrete Trombe wall (see Glossary) that rises to ceiling height immediately inside the glass on the south side. This wall is part of one of the systems used to heat the house.



A facing of smooth-worn river rocks makes Kirby's Trombe wall a handsome addition to the house interior.

Massive fireplace near the center of the house is a major heat contributor.

house's solar heating capacity. Plans also include completing the built-in greenhouse on the southeast side.

Warm Rocks

The Kirby house contains a large volume of thermal mass. Besides the massive fireplace and Trombe wall, interior stone walls provide capacity for considerable heat storage. Jay said it takes several days to warm up all this mass, but that once warm, the house requires little additional heating to stay at a comfortable temperature. Backup heat is provided by electric baseboard heaters and two electric fan heaters that can take the chill off until the fireplace warms the living space. A small wood-burning stove on the main floor directly under the apex of the house also provides additional heat when necessary.

Other Ways of Heating Water

Among the various energy-saving strategies employed in the house are two ideas for saving money on water heating. The first of these is already operating, and uses a holding tank near the fireplace to retain well water for a time before it is moved to the electric water heater. Water in the tank warms to room temperature or a little above, Jay said, adding, "This way, we only have to heat it from 75 degrees to 120, rather than from 40 to 120." Looking to the improvement of this system, Jay wrapped 33 feet of half-inch copper tubing around the fireplace flue inside the masonry. Eventually, this tubing will be used to heat water for household use, he said.

A House in the Round

The rounded shape of the Kirby house helps energy efficiency by requiring less outside wall surface to contain a given floor space than a rectangular structure would require. Less wall means less heat lost to the outside.

A Well-considered Compromise

Despite Kirby's painstaking efforts to enhance the energy-saving qualities of his house, he said that his main emphasis was on livability, of which energy efficiency is only one aspect. Good design, including careful planning and siting, should enhance both energy efficiency and livability, Jay said. For example, he said, design features that let plenty of light into the living space serve both purposes. In the Kirby house, light passing through the windows in the roof dome streams down into the atrium in the central area. Each of the four bedrooms has a window into the central atrium and a window to the outside above the level of the earth berm.

A Lot of Building Ideas, Mostly Good

Jay said building this unusual house gave him the chance to try out a lot of building ideas he developed over the years. Some of these ideas worked and some left room for improvement. For example, the sloped windows in the geodesic dome are much more prone to leaking than vertical glazing.

Another possible change would be the use of modular concrete roof panels. These could be put up in one day and would cut down on construction time and cost.

How Much it Cost

One concern in the construction of nonstandard structures such as the Kirby house is costs that result from the builders' lack of know-how with unfamiliar building methods. Kirby built his house himself over a period of years and so saved labor costs. He said he has about $35,000 in materials in the nearly finished structure. He estimated it would cost about $85,000 to hire a professional contractor to build a similar house. That works out to $50 per square foot.

Energy Consumption Not Yet Established

No reliable estimate of the house's energy consumption is available. Pending completion of the finishing touches, the Kirbys are not living in the house and have not established its energy consumption, though they often spend weekends there and report that it retains heat well.

Jury Still Out

Kirby does not subscribe to the conventional idea that nonstandard houses are more difficult to resell than less exotic designs. In support of this idea, he notes that two clients who saw the house have commissioned him to design similar structures, one of which has since been built near Ronan (see write-up on Ron Trosper's house).

The Montana Vernacular may not be for everybody, and may not be the last word in energy efficiency, but it does provide a style of living that could please many Montanans by its combination of traditional Montana building materials and styles with modern energy-saving technology. □

RSDP Construction Saves Kilowatts

Owners
Kent and Mae Bolstad

Location
Bigfork

Designer
Mike Torgerson
Architectural Energy Development
P.O. Box 186
Bigfork, MT 59911
837-6832

Builder
Larry Hill and Dan Day
P.O. Box 215
Bigfork, MT 59911
837-4163, 837-5226

Style
1 Story with Walk-out Basement

Insulation
Ceiling - R45
Double Wall - R37
Basement Wall - R25
Slab - R5

Square Feet
Main - 1,224
Basement - 1,232

Special Features
RSDP Construction
Berming
Overhang

Heat
Electric Radiant Ceiling

Completed
December 1984

Kent and Mae Bolstad were the first to build an energy-efficient house in the piney woods of Ferndale, near Bigfork, but they aren't the last. Neighbors who saw the Bolstads basking in their warm, super-insulated house and gloating over their low heat bills decided to get in on the action and build their own warm places.

Heating the Bolstad house for a year required 3.77 kilowatt-hours (kWh) per square foot. To heat a house built to HUD standards for a year required an average of 6.58 kWh per square foot in northwestern Montana. At a rate of $0.05 per kWh, it cost $464 to heat the Bolstad's house for a year compared to $810 to heat a HUD house of similar size in the same location.

Double wall construction and berming affords warm living in Kent and Mae Bolstad's cedar house despite winter snows. Framing on the roof is for future installation of a solar collector.

Integrating RSDP

So what made the difference in the kilowatts used? "Building to Residential Standards Demonstration Program (RSDP) specifications," Kent said. "Mike Torgerson (the designer) knew about energy-efficient construction and the RSDP. Mae and I wanted a solar house; Mike helped us fit the plan to RSDP specifications."

Designed to save space heating costs in electrically-heated houses, the RSDP offered incentives for incorporating certain energy-efficient features into new houses. To meet RSDP specifications for reducing the number of kilowatts needed to heat their house, the Bolstads combined high levels of insulation and air-tightness with a design that makes use of solar heat. The energy-efficient improvements added about $5,500 to the cost of the construction.

Double wall construction in the upper level of the house—an interior 2 x 4 wall and an exterior 2 x 6 wall—provides room for R13 and R19 fiberglass batts. Sheathing of 3/4-inch polyisocyanurate foam board adds an R-value of 5 to the walls. Raised heel trusses make room for blown-in fiberglass to R45. Earth berming shelters the lower level of the house on three sides. The 8-inch basement walls are sheathed on the exterior with 3-inch extruded polystyrene foam board. A 4-inch concrete slab rests on a layer of 2-inch gravel fill. A 6-mil polyethylene air-vapor barrier and 1-inch extruded polystyrene foam board provide moisture and thermal barriers beneath the slab and the gravel fill.

Although an air-vapor barrier of 6-mil polyethylene tightly seals the house between the two stud walls in the double wall and in the ceiling, Kent went a step further. "I was a little concerned about moisture entering the interior surface of the wall," he said, "so I painted the walls and ceiling with Glidden vapor barrier paint. In my job at a retail paint and wallpaper store, I had been working with Pacific Power and Light Company which was specifying vapor barrier paint for certain types of construction. I decided to put it in my own house. It goes on like regular paint, but it costs a bit more."

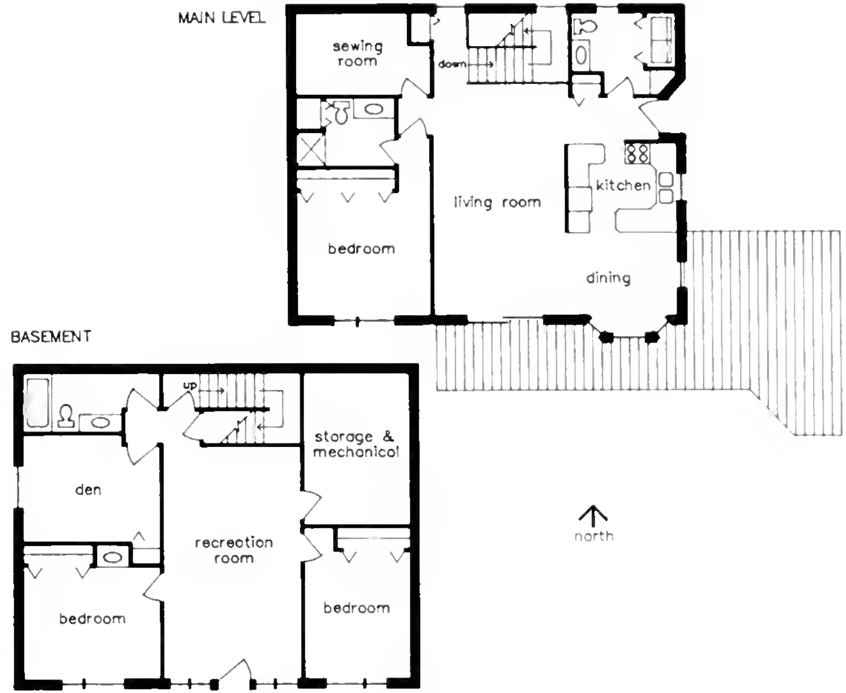
Electric Heat Supplemented by Solar

Electric coils embedded in ceiling drywall provide radiant heat throughout the house. Total rated capacity of the coils is about 10,000 watts, distributed as follows. 3,340 watts in the living-dining-kitchen area, 1,195 watts in the master bedroom, 450 watts in the sewing room, 2,390 watts in the recreation room, 475 watts in each downstairs bedroom and the den, and 245 watts in each of the three bathrooms.

"Having the heat panels in the ceiling means we can place our furniture anywhere, no need to worry about baseboards or registers," Mae said. "It's also a steady, even heat. We maintain the thermostats at 68 degrees."

Facing the house to look south out over the airstrip served more of a purpose than to keep an eye on Kent's Cessna 150. Windows and the large opening in the forest required by the airstrip open the south side of the house to light and sun. "On a clear day, we get plenty of solar heat in here, even though it may be minus 20 degrees outside," Kent said. "And even on foggy days, we get some heat." Verosol pleated shades are lowered to cover the triple-glazed windows on winter nights to slow heat loss. In the summer, the shades help keep out the hot sun during the day. "What is critical, though," Kent said, "is the 3-foot overhang that admits the low-angle rays from the winter sun, but in summer keeps them from cooking us."

"If we had it to do over, we'd somehow achieve as much solar gain downstairs as we have upstairs," Mae said. "There's a big difference in the amount of electric heat needed between the two floors; the downstairs simply doesn't get enough sun."



A cantilevered dining area with a south-facing bay window provides a sunny space for Kent and Mae Bolstad to sip coffee and watch the deer outside. All windows are triple glazed.

Fresh Air and a Clean House

To keep fresh air circulating in the tight house, an EZ Vent heat recovery ventilator runs continuously at the lowest setting of the variable speed control. When the outside temperature drops to 34 degrees, a defroster in the unit periodically recycles warm air through the ventilator to prevent ice buildup on its core. "We have no moisture problems anywhere in the house," Kent said. "Mike designed the ventilator and ducting system carefully for the size and layout of the house. It's incredible how fresh and dust-free the house is. It's the cleanest house we've ever lived in." □

Striving for the Zero Heating Bill

Owners
Jerry and Lois Dalton

Location
Billings

Designer
Jerry Dalton and Rick Barta

Builder

Barta and Sun
5720 Homer Davis
Shepherd, MT 59079
373-6753

Style
1 1/2 Story with Unfinished Basement

Insulation
Ceiling - R60
Double Wall - R45
Basement Wall - R19
Slab - R10

Square Feet
Upper - 500
Main - 1,200

Special Features
Superinsulation
Low-E Triple-pane Windows

Heat
Passive Solar, Natural Gas

Completed
December 1985

It wasn't that Jerry and Lois Dalton's old house in Billings was an energy hog. "It had plaster walls, and was pretty well sealed," Jerry said. But that wasn't enough. Jerry was a member of AERO, the Alternative Energy Resource Organization, and he was more than ordinarily interested in saving energy. "My goal was to pay zero for space heating," he said.

Aiming at paying zero for heat, Jerry and Lois decided they needed a new house with state-of-the-art energy-saving technology. They knew that builder Rick Barta was interested in houses of this type, so they hired him to help with the plan and do the construction. The finished product shows the handsome side of energy efficiency. With a total of 1,700 square feet on two floors, and with an unfinished basement that can be finished to provide substantially more space, the Dalton house has plenty of room to go along with modern style and energy efficiency. It fits comfortably into the prosperous Billings neighborhood where it is located.

The Daltons' comfortable house in Billings. Note foliage that shades the windows in summer.

A Plethora of Energy-saving Features

The house's energy efficiency results primarily from the double-wall, superinsulated construction. Each of the 2 x 4 stud walls in the 13-inch double wall has R11 fiberglass batts, with R19 batts in the space between. Total R-value of the walls with drywall and siding is 45. Ceiling insulation is blown-in fiberglass to R60. The vaulted portion of the ceiling is insulated with three layers of R19 batts. Basement walls are furred out with 2 x 4 studs and insulated with R19 batts. Two inches of extruded polystyrene under the slab have an R value of 10. A 4-mil TuTuff air-vapor barrier was installed on the back side of the inner stud wall.

All windows are Weathershield triple pane with low-E coating. If he had it to do over, Jerry said he would not go with the triple-pane low-E. "It added $500 to the cost of the windows, it reduced the growth of our house plants, and worst of all, it always looks dirty," Jerry said.

(DNRC building specialists note that the use of low-E glass in double-pane windows avoids most of the problems Jerry noted and is substantially cheaper than low-E triple pane, with a much shorter payback period. Home owner experience indicates that double-pane low-E is the best compromise. Double-pane low-E costs 15 percent more than plain double pane but is almost as effective as triple-pane low-E in preventing heat loss. Standard double pane admits 82 percent of the light striking it, compared to 74 percent for double pane with low-E, and 68 percent for triple pane with low-E.)

Most of the Daltons' glazing is on the south side for passive solar heating. The north side has only three small windows.

Fresh Air, No Cold Spots

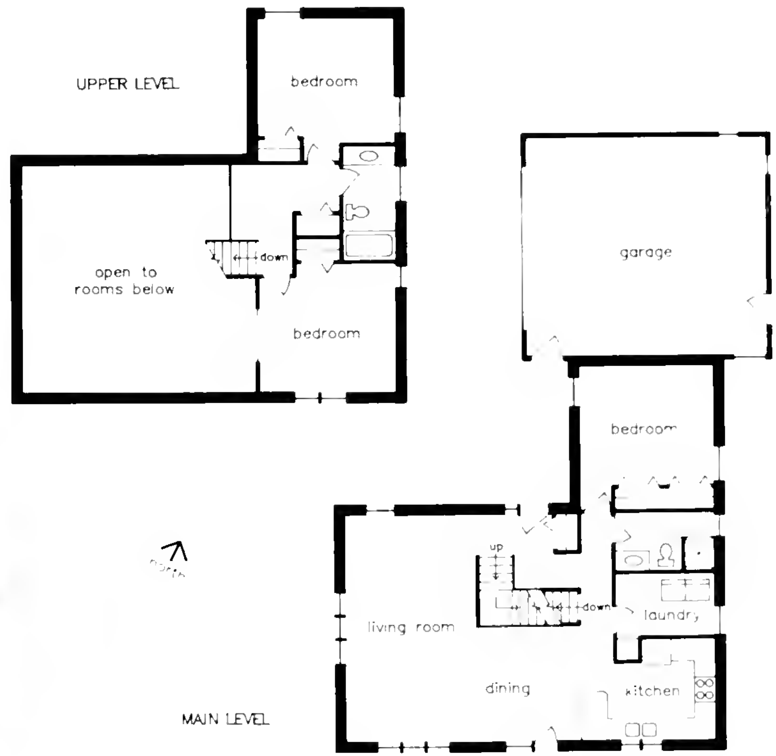
Space heat and domestic hot water heating are provided by a Weil McLain

Draft-free atrium patio doors lead to the kitchen and dining area in the Dalton house.

gas-fired, direct-vent 50,000 Btu boiler. Sometimes neither of the Daltons is home during the day, but they do not set the thermostat back. "It simply is not worth it to mess with the thermostat," Jerry said. One of the benefits of superinsulation is the uniform warmth throughout the house. "There are no cold spots," Jerry said. A VanEE heat recovery ventilator keeps the air fresh in the house.

Cost to build the house, exclusive of land, was approximately $74,000, which comes to $43.50 per square foot of finished space. Barta estimated that the superinsulation equipment, materials, and extra labor added about $5,000 to the cost of the house. The payback period on this $5,000 would be about eight years at current utility prices, though payback is likely to be quicker as energy prices escalate with time.

Even though the Daltons have not yet trimmed their heat bill to zero, they seem to be on the right track. Their total heating cost for 1986 was $130. □



Going Underground

Owners
Clarke and Chris Elliott

Location
Billings

Designer
Rick Barta and
Building Specialties, Inc.
195 Lexington Drive
Billings, Montana 59102

Builder
Barta and Sun
5720 Homer Davis
Shepherd, MT 59079
373-6753

Style
Underground, Single Level

Insulation
Ceiling - R38
South Wall - R19
Below-grade Concrete Walls - R10
Roof - R10

Square Feet
Main - 2,000

Special Features
Full Underground Design
Metal Roof Trusses

Heat
Passive Solar, Wood and Coal

Completed
1986

Building technology has come a long way since homesteaders in eastern Montana stayed snug in dugout shelters or sod houses, but many people in those parts are still nostalgic for living quarters sheltered by the earth. Modern materials and building methods make the underground house easier to build than ever before, although the structural strength needed to support a dirt roof tends to drive costs up.

Chris and Clarke Elliott did some research on the topic and confirmed that they wanted to build an underground house, even though their inquiries discovered some of the things that can go wrong with such structures. For example, underground houses can be gloomy if not properly designed and built. The Elliotts even found one that was built facing north.

When the Elliotts were ready to have their underground house built, they had just the right place for it: the south-facing edge of a ravine in the hills south of Billings. Off to the south was a pleasant view of junipers and pines, with no big trees or other obstacles to sunlight. They hired an engineer to draw up a structural plan, and Rick Barta to design the energy efficiency features, and soon they had a big hole in the ground that was the physical beginning of their house. That was in 1983. Building proceeded at a leisurely off-and-on pace as money was available and other projects allowed, and it wasn't until 1986 that the house was finished and the Elliotts went underground.

The Elliotts' house faces south across a deep ravine.

An Easy Heater

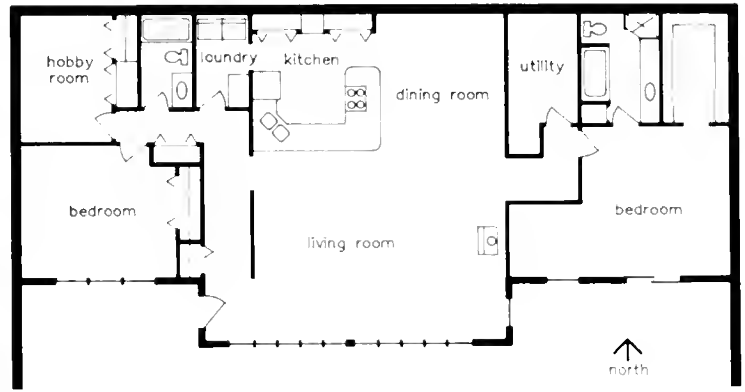
Clarke said they used about 500 pounds of coal and 3/4 of a cord of wood in their first heating season in the house. Coal sells for about $90 per ton, so the 500 pounds added approximately $22.50 to the heating bill. The Elliotts' Gibraltar wood/coal stove is their sole source of heat other than the sunlight that floods in through the big windows on the south side. "On New Years Eve we had some people over and it got so warm in here we had to open the windows, even though it was zero degrees outside and the stove was not lit," Clarke said. Chris complained good naturedly that she often has to open the windows when she gets home from work, because Clarke and their daughter get home first and build a fire that quickly overheats the living space. Even drying the clothes can provide more heat than needed inside the house. "We've changed our lifestyle a little," Chris said. "I wash a load a day instead of doing all the laundry on Saturday."

A Clean, Well-lighted Place

Besides being an easy heater, the Elliott house is a nice place to live. Bright and airy inside, every room has natural daylight except the small sewing room at the northwest corner. This comfort is not the result of an accident,

The west side of the Elliott house. Some backfilling remains to be done.

South-facing windows look out on the natural landscape, with no hint that the house is underground. Most heat is provided by sun through the windows, with backup by coal-wood stove at left.



but comes from good planning and design. Given the right kind of preparation and construction, underground houses can be first quality living space. However, structural flaws that might not even be noticed in conventional construction invite disaster in underground building. Consider, for illustrative purposes, that the 18-inch earth cover on the Elliotts' roof weighs about 280,000 pounds.

Steel Web Trusses

Roof support is always a major consideration in underground houses. The engineer the Elliotts hired calculated the roof stresses and came up with a structural design to support the weight. The key to the design was steel web trusses, installed 2 feet on centers and supported at midspan by a steel I-beam. The maximum span of the trusses is 16 feet.

Corrugated 24-gauge galvanized roofing was laid across the trusses, and 3 inches of reinforced 5-bag concrete was then poured over it. A Bituthane membrane was applied over the concrete, followed by 2 inches of extruded polystyrene, 2 inches of sand, 10 inches of clay soil, and 6 inches of topsoil.

Twelve inches of fiberglass insulation were blown into the spaces among the steel web trusses. Two-inch extruded polystyrene sheets were applied to the outside of concrete walls and to the foundation wall across the front. The under side of the floor slab is insulated along the southern edge with a 2-foot wide sheet of 2-inch extruded polystyrene. The inner surface of the concrete walls is not insulated, but is finished with drywall. Leaving the inner surface of the walls uninsulated allows them to function as thermal collectors, soaking up heat during the warm part of the day and releasing it when the air cools.

Now that the Elliotts have been subterranean for more than a year, they are more enthusiastic than ever about their underground house. "We wouldn't do a thing different," they said, "except maybe make the master bath bigger and the closet and storage space a little smaller." Cost of the Elliotts' house, exclusive of land and utilities, was $74,000, or about $37 per square foot. □

A Question of Payback

Owners
Jay and Irene Foley

Location
Billings

Designer
Rick Barta

Builder
Barta and Sun
5720 Homer Davis
Shepherd, MT 59079
373-6753

Style
Single Level with Basement

Insulation
Ceiling - R38
Walls - R19
Basement Walls - R19

Square Feet
Main - 1,250
Basement - 800

Special Features
Heat-recovery Ventilator
Domestic Water Heater

Heat
Natural Gas Hydronic System

Completed
November 1987

One of the big questions when building an energy-efficient house is, how much money should be invested to save energy? It is possible to spend so much money on energy efficiency that it can never be paid back by the savings.

Jay and Irene Foley of Billings pondered this question as most people would when setting out to build a new house, and came up with an answer that suits them. They worked with builder Rick Barta to design a house that has modest construction costs coupled with big energy savings, and is still more than sufficiently stylish to hold its own on Rimrock Drive in Billings.

As designed and built by Barta, the house has 1,250 square feet on the main floor, with 800 square feet of finished space in the basement. The exterior walls are 2 x 6 studs with R19 fiberglass batts. The attic is insulated with blown-in fiberglass to R38. The finished portion of the basement has a 2 x 4 stud wall with fiberglass batts to R19. No insulation was placed under the slab.

Large windows on the south side of the Foley house capture the sun.

Strategy for Saving Energy

Barta installed a continuous polyethylene vapor barrier. A Vent-aire heat recovery ventilator brings air from outside through a buried pipe which warms the air to earth temperature in cold weather and prevents freezing of the ventilator system. Windows are standard double pane. Large windows on the south side provide passive solar heating, and clerestory windows brighten the living space.

The heating system used in the house is a relatively new type which Barta said works well in energy-efficient houses. This system is based primarily on a coil that operates with hot water from the domestic hot water heater to warm air brought from outside by the heat recovery ventilator. The extra fixtures needed to adapt the hot water heater for space heating add about $200 to its cost. Ventilation requirements are minimum with this unit, because intake air and exhaust gases both pass through the same double-wall flue.

Questions of Efficiency

"The efficiency of this type of heating system is less than that of a high-efficiency gas furnace, but the cost is hundreds of dollars less, the exact figures depending on heating requirements and other variables," Barta said. He estimated the efficiency of the hot-water heater to be about 80 percent, noting that efficiency would vary depending on how much hot water is used for household purposes.

Low Bills Predicted

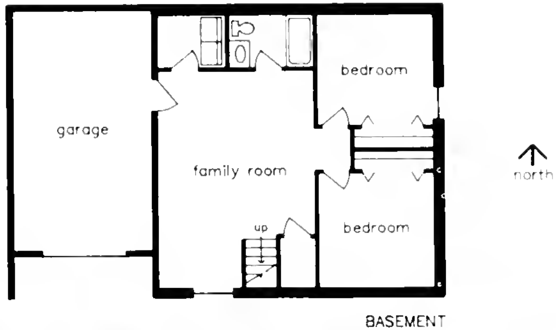
The Foleys had not moved into their house at the time of DNRC's visit in late

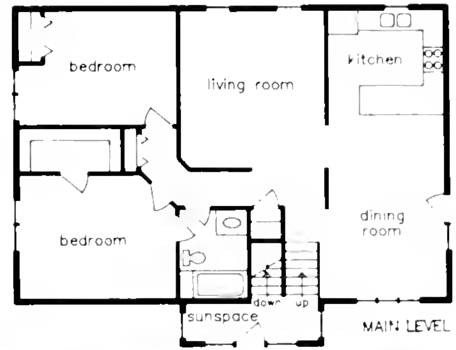
fall, so there are no hard data on heating costs. However, three separate computer programs developed for predicting heat bills indicate that annual costs will be approximately $140. Heat bills this low indicate that only small additional amounts of energy would be saved by installing more insulation or a high-efficiency furnace, and that the savings would not pay back the higher cost of the furnace. If the Foley house did not have access to natural gas, the story might be different. DNRC calculations indicate it would cost about $375 a year to heat the Foley house with electricity, which might make it economical to install more insulation.

One of the goals in energy-efficient construction is to have no more than one combustion device in a house, minimizing the amount of combustion air needed and requiring only one flue through the roof or outer wall. This approach requires that domestic hot water heating and space heating be combined in the same combustion unit. The two functions can be combined either by using a high-efficiency furnace with built-in water heater, or by using the hot water heater for space heating, as in the Foley house. Although natural gas is more economical to use, electric space heating and hot-water heating avoid the problems associated with combustion units.

Money Spent, Money Saved

Having saved money on their space-heating equipment, the Foleys also were pleased with the total bill for building their new house, which came to about $55,000. This is about $24.40 per square foot of usable space, if the finished basement space is included in the calculation. □





A view from the dining room in the Foley house. Double-paned windows and atrium doors reduce heat loss

Indoor Swimming Pool Enhances Efficient Home

Owners
Steven and Gwayne Kramer

Location
Billings

Designer
Steven L. Kramer
3206 Viola
Billings, MT 59102
652-3240

Builder
Schooner Realty &
Development, Inc.
3206 Viola
Billings, MT 59102
652-3240

Style
Split Entry Multi-Level

Insulation
Ceiling - R60
2 x 6 Wall - R27
Basement Wall - R6

Square Feet
Loft - 252
Main - 1,972
Basement - 1,184
Pool Room - 1,288

Special Features
Solar-heated Swimming Pool
Ground-coupled Cooling Tube
On-demand Water Heater
85%-Efficient Furnace

Heat
Natural Gas

Completed
August 1984

Can a highly insulated house have a swimming pool in the basement and not be dripping with condensation? "Definitely," said Steve Kramer of Billings. "Humidity isn't a problem in our house. In fact, we open the door to the pool room because the rest of the house is too dry. Our cupboards even shrank from lack of humidity. Indoor pools aren't the problem people expect, and you don't have the heat loss that you do with outdoor pools."

Although the Kramers installed two heat recovery ventilators—one for the pool and one for the rest of the house—they don't use them much. "About the only time we use the house ventilator is to vent humidity out of the bathroom after we shower," Steve said.

Solar panels on the roof of Steve and Gwayne Kramer's house (between the two vent stacks) heat the water for the indoor swimming pool. South-facing windows and a concrete slab around the pool add thermal storage.

Sunlight and Earth Warm Basement Pool

To keep the pool warm, a roof-mounted solar heating system operates eight months of the year. During the other four months, the Kramers heat the 448-square-foot pool with gas for about $50 a month. Steve noted that he used DNRC's "Solar Data" book to properly orient the solar panels.

The bottom of the uninsulated swimming pool is 4 feet below the basement floor, and 9 feet below the ground surface. "When we were building the house, the swimming pool was in but not heated," Steve said. "Although the outside temperature registered 30 below, the room gained enough heat from the sun and earth so that we never had to use a heater to stay above freezing."

Part of the pool room's ceiling is a pre-stressed concrete slab that doubles as a garage floor. Part of the slab rests on the ground and is insulated underneath with 1 1/2-inch extruded polystyrene foam board, laid over a moisture barrier of 8-mil polyethylene.

Earth Cools House

The swimming pool is just one of several special features in Steve and Gwayne Kramer's house. For cooling in Billings' hot summers, the Kramers rely on a ground-coupled cooling tube. On hot days a pump circulates water continuously from a water coil in their gas furnace through approximately 440 feet of PVC pipe placed 9 feet below ground, winding around the foundation, and back. Steve noted that the pipe had to be more than 7 feet deep to take advantage of the stable, ambient temperature of the earth. The furnace fan blows hot house air through the water coil which absorbs the heat. The cooled air is distributed through the furnace ductwork. "Not a lot of literature exists on earth cooling tubes, so I took a seat-of-the-pants guess on the amount of pipe I needed," Steve said. "We hooked it up last summer and it cooled the house fairly quickly, so I guess we have enough pipe."

Using On-demand Hot Water

For domestic hot water, the Kramers use a Thermar instant water heater. The 100,000 Btu heater kicks on when the flow of water past it reaches a certain speed, such as that demanded for a shower. "With the instant heater," Steve said, "we could take showers all day long and not run out of hot water. If somebody else in the house is using hot water, we can put the showers on half flow so there's plenty to go around."

But he cautions that adjusting these heaters can be tricky. "Others contemplating on-demand heaters," Steve emphasized, "should pay attention to the installation. Many plumbers aren't familiar with the heaters and don't know how to adjust them for proper performance. It's similar to tuning a carburetor, but in this case, the components are gas feed, air bleeder, and water pressure valve."

Steve said that using an on-demand heater means appliances have to be purchased or adjusted to adapt to the heater. "A dishwasher should have a preheater. The small volume of water it uses doesn't cause enough flow to turn on the water heater," he explained. "Clothes washing has to be done in either cold or hot water. On the warm cycle the regulator in a washing machine feeds in so much cold water in relation to the hot that the flow isn't enough to kick on the heater."

But this kind of heater isn't for everybody. "Although we love the Thermar," Steve said, "people who take lots of baths aren't going to be impressed. The slower flow means the tub doesn't fill rapidly." He added a tip: "A small holding tank (about 15 gallons) ahead of the heater starts water heating to room temperature, reducing the time and amount of energy needed to heat water."

Building Techniques Save Energy

The house faces almost due south. Most of the windows are on the south side and all windows are triple glazed. The walls are 2 x 6 with R19 fiberglass batts. "In 1977, the codes changed to let us put 2 x 6 studs on 2-foot centers," Steve said, "and since then we use them on all the houses we build. There's less twisting and shrinking with 2 x 6 studs." He also uses drywall clips exclusively so he can place more insulation in the walls. Drywall clips replace studs that are used only as backing to secure drywall.

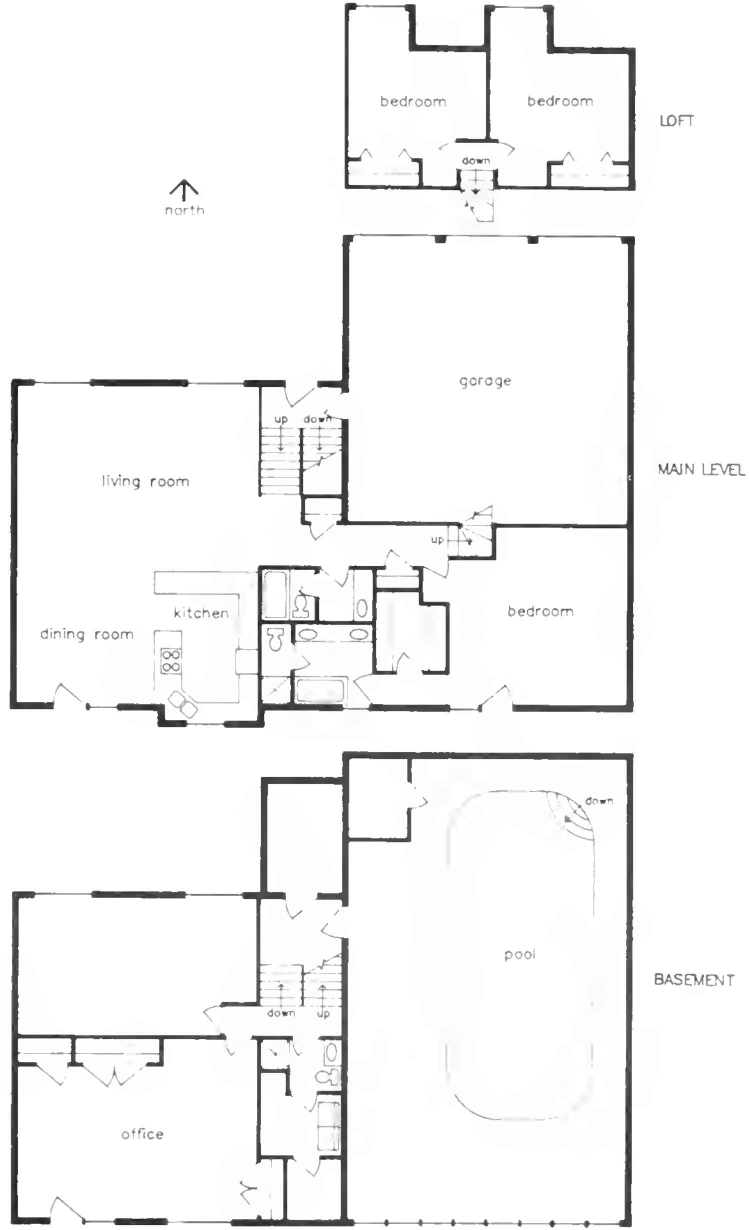
Steve pointed out the almost 2-foot depth at the heel of the trusses which "allows for rock wool knee-deep in the ceiling."

Care Taken on Air and Vapor Barriers

"What helps make this house work," Steve said, "is no air infiltration. We used 3/4-inch foil-faced polyisocyanurate foam sheathing on the exterior. But, we didn't apply it when we framed. The siding and the sheathing went up at the same time so the wind didn't blow against the sheathing and stretch the nail holes."

Ron Kimmell, foreman on the building job, noted the extra care taken on the air-vapor barrier. "We sealed the 8-mil polyethylene with a special caulk that never hardens, and used a double row of caulk on the polyethylene overlaps. We repaired the polyethylene after the framers, electricians, and plumbers were finished," Ron emphasized. "We also caulked under the sills while we were framing, and went through the house sealing all openings and cracks with expanded foam."

Steve briefly reviewed other energy-saving features in the house. "The front door is insulated steel. We used French



patio doors in the dining room and the pool room. French doors don't have the air infiltration of patio sliding doors, and are trouble free," he said.

Drywall Tips

Steve had some suggestions for those installing drywall. "They need to adapt to these tight houses and use screws instead of nails," he said. "In superinsulated houses, the bottom chord of the truss lies under a thick layer of insulation which keeps the chord dry and warm, and may cause it to shrink a bit, especially in the first year. The top chord is above the insulation and is surrounded by cold air and perhaps even moisture which can cause it to expand and elongate. The difference in length of the two chords can cause the truss to bow slightly upwards, moving the drywall. When you nail drywall sheets at the top, the movement of the trusses pops the nails. Same problem with the ceiling. Ceiling drywall moves as the trusses expand and contract. Drywall screws have greater holding power than nails, and they don't back out under stress."

Second Thoughts on Heating

The construction strategies are working. "We have no drafts. When the wind blows, we aren't aware of it. We are losing so little heat," Steve said, "that if I had it to do over, I'd use baseboard heaters. The gas furnace, rated at 85,000 Btu, doesn't operate at total efficiency because it isn't running very long at a time." In January 1987, Steve added a small airtight wood stove to heat his office in the lower level. "I didn't want to heat the whole house when I just needed heat in here," he explained.

Open and Bright

At the home's center, waist-high cabinets separate the kitchen from the living and dining areas. "I like a large open room," Gwayne said. "When I'm in the kitchen I don't want to be isolated from the rest of the family."

Steve laid his hand on the heavy gray-brown tile on the countertop. "One thing that surprised us," he said, "is what thermal storage this tile and the drywall have. We turned the heat down to 55 degrees and left for eight days last winter. The house stayed at 62 degrees even though it got as low as 13 degrees outside. But the mass also means that it takes time to warm up," he added. "Once it's warm, though, it stays warm with little heat."

Between the living area and the master bedroom, a skylight brightens the bath and hallway. "The skylight is a trade-off between some air leakage and a saving in electricity," Steve commented. South-facing French doors in the bedroom admit more sunlight and heat. A loft above the garage houses two bedrooms and an attic.

More south-facing French doors admit sun to warm the downstairs office. Oak parquet covers the basement's concrete slab which serves as thermal storage. "The parquet is also good because it doesn't build the static electricity that could damage my desktop computer," Steve noted

An open floor plan and vaulted ceilings promote air circulation. Sunlight streams through the French doors leading to the deck.

Costing It Out

"We tried to build an efficient house without sacrificing aesthetics or going broke," Steve said. "This house surpasses the energy savings we'd hoped for. Our highest gas bill was $154, and $50 of that was for the pool. We average $62.14 a month for space, water, and pool heating.

"To build a similar house would cost between $60 and $70 a square foot, including the pool. Approximately $2,500 of this is for the solar panels, and another $750 for the cooling tube installation

"People have to be convinced to pay for energy extras," Steve said. "But what satisfaction it is to get a low gas bill and not have to sacrifice comfort." □

House Shuts out Cold, Welcomes in Sun

Tom Parker, avid duck hunter and ex-trapper, knows first-hand the value of thick clothing against fierce Montana winter weather. But he didn't care to ramble around his house wrapped in heavy clothes to keep warm, nor did he want to spend his paycheck on heating fuel. So he and his wife, Peggy, decided a superinsulated home would be the ticket.

"I'd been reading about energy-saving houses for years, and spent two years walking through houses seeing how they were put together," Tom said. "My biggest problem was finding someone who knew how to build one. I finally ran across Gordon Aldinger, who'd spent some time at the Saskatoon energy-efficient housing project conducted by the Canadian government."

The north side has only one window, minimizing the passage of street noise and heat. All windows are triple pane with low-E coating. An insulated metal door opens to the front porch.

French doors opening to the decks are insulated metal with double-glazed low-E glass. The doors allow entry to the southeast deck (above) from the kitchen and spa room, and to a south deck from the master bedroom.

Tom's research and Gordon's skills meshed to produce a house frugal in energy use. Located on the edge of open fields east of Billings, the house gets plenty of cold blasts from the wind. But, from November to March, monthly gas bills averaged just $41 for space and water heating, of which Tom estimates $15 to $18 was for heating water. "When the sun shines, the furnace rarely comes on," Tom said. The Parkers keep the daytime temperature at 70 degrees, setting the thermostat back to 65 at night.

Double Walls Foil Cold

Heavy insulation buffers the house from the extremes of Montana weather.

Owners
Tom and Peggy Parker

Location
Billings

Designer
Owners

Builder
Gordon Aldinger
Aldinger Homes
4704 North Woodhaven Way
Billings, MT 59106
652-2644

Style
1 Story with Basement

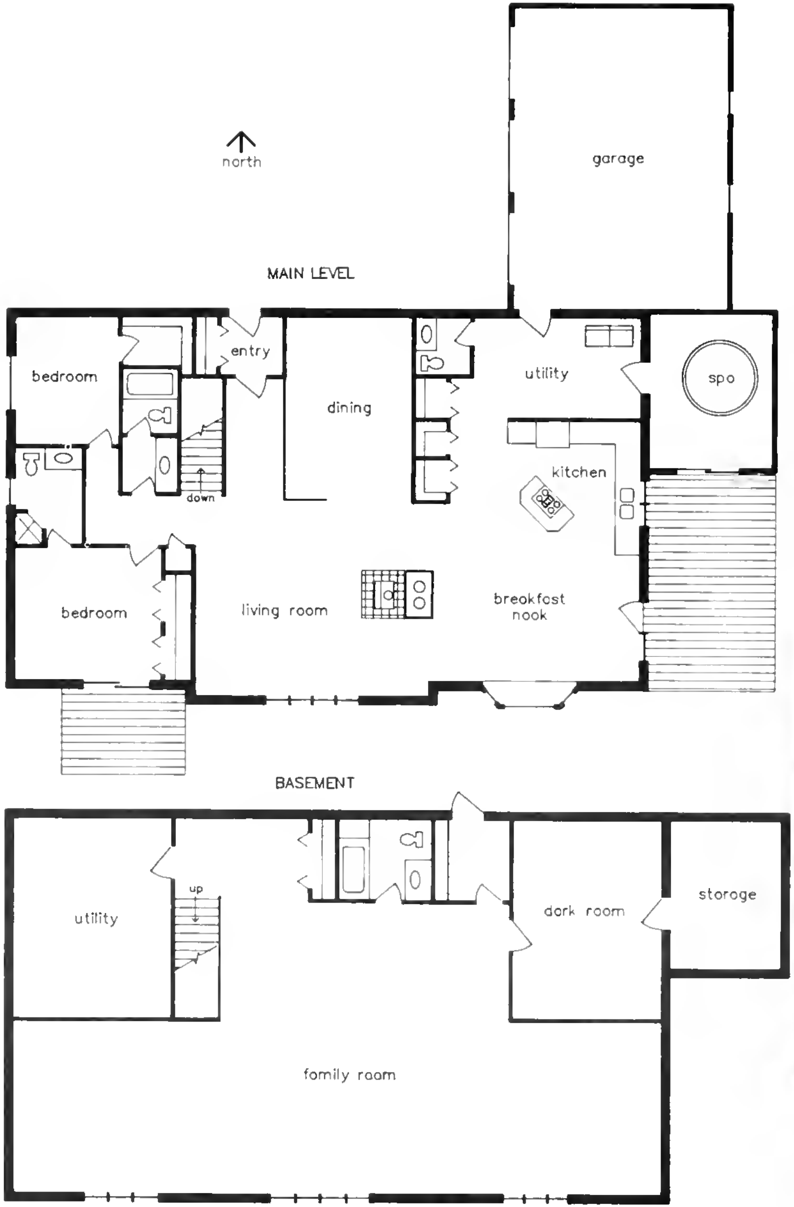
Insulation
Ceiling - R60
Double Wall - R30
Basement Wall - R29

Square Feet
Main Floor - 2,475
Basement - 2,475

Special Features
Sealed Combustion Gas Appliance

Heat
Natural Gas

Completed
February 1986



Two-inch extruded polystyrene sheathes the outside of the 8-inch concrete basement wall, and an insulated 2 x 6 wall was installed on the interior.

On the main floor, double walls built with two 2 x 4 walls spaced 2 inches apart hold two layers of fiberglass batts—one R19 and the other R11. A continuous 6-mil polyethylene air-vapor barrier caulked with acoustical sealant at all seams keeps moisture out of wall cavities. Beneath the Masonite siding, Tyvek protects the exterior plywood, preventing frigid air from creeping into the house. In the roof, raised-heel trusses provide room for R60 blown-in fiberglass insulation from outside wall to outside wall. The garage has insulated 2 x 4 walls.

It was evident early on that the home's superinsulated walls would keep out the cold. "Even before we insulated the ceiling, and when some of the window holes just had polyethylene covering them, the house stayed around 45 degrees despite sub-zero temperatures outside," Tom said.

Controlling Humidity

A dehumidistat-controlled VanEE-2000 heat recovery ventilator periodically draws fresh air through the house, and exhausts stale air. "We have to watch the weather report," Tom said. "If we're in for a real cold snap, we kick the dehumidistat down so the ventilator turns on at a lower humidity level to prevent condensation from forming on the windows. The first time the temperature dropped like that, it caused a lot of condensation and the shades froze to the window."

Generous windows on the south bring in heat and light from the sun The massive chimney from the wood stove does multiple duty, separating the living room from the kitchen, and absorbing heat both from the low-lying winter sun and from the wood stove, and releasing it at night to warm the house.

Parquet floors in the country kitchen complement the early American wallpaper and oiled oak cabinets. On the upper glass cabinet doors, peach-hued swirls of stained glass echo the color of the antique sideboard doors. A suspended ceiling conceals a bank of efficient fluorescent tubes. In the entire house, only four ceiling lights penetrate the air-vapor barrier

Insulation beneath and around the spa tub and an insulated cover minimize heat dissipation from the water. The spa room has its own exhaust duct into the heat recovery ventilator system, and Tom said moisture in the room had never been a problem.

Steel Doors Save Heat, Don't Warp

The Parkers chose insulated steel exterior doors to prevent heat loss and to avoid warp. "When one side of the door is exposed to a warm and relatively humid environment and the other side is exposed to dry, cold air, the wood expands and contracts differently. Over time this may cause the door to warp," Tom explained.

Heating With Gas

A 93-percent efficient Carrier Weatherman SX furnace rated at 60,000 Btu supplies the space heat. The compact furnace requires just a few square feet of floor space in the basement. A wood stove was installed in the living room, but isn't in use yet. Tom is improving on it to make it truly airtight. It will eventually contribute to the space heat.

Because the superinsulation substantially cuts the amount of air coming into the house from the outside, the Parkers paid particular attention to the combustion air needs of their gas appliances and wood stove. Ducts bring outside air directly to the furnace, water heater, and firebox of the wood stove. "We chose a State Turbo Saver gas water heater because it is one of the few which has a sealed combustion unit," Tom said. "The heater flue is a pipe within a pipe. The inner pipe brings in outside air and the outside pipe exhausts the hot gasses. The heater is also well insulated." Because of the low temperature of the exhaust from the condensing gas furnace, the flue is PVC pipe and exits through a wall, eliminating a penetration in the ceiling air-vapor barrier.

"We're real happy with the house," Tom said. "It's so quiet we hardly realize we have neighbors. Gordon's workmanship is excellent." □

Blunting the Intrusions of Weather and Water

Owners
Jack and Sheryl Winkle

Location
Billings

Designer and Builder
Aldinger Homes
4704 North Woodhaven Way
Billings, MT 59106
652-2644

Style
Multilevel Split

Insulation
Ceiling - R50
Double Wall - R30
Family Room Slab - R5
Crawl Space Walls - R5
Basement Wall - R11

Square Feet
Upper - 780
Main - 1,728
Basement - 630

Special Features
83% Efficient Furnace
Outside Combustion Air

Heat
Natural Gas, Wood

Completed
February 1985

Located in the middle of flat cornfields to the west of Billings, Jack and Sheryl Winkle's house stands up to strong winds, thick dust, and rising water on a regular basis and performs like a champ. "We simply didn't realize the heavy southwest winds that roar through here when we picked this spot," Jack said. "One night we thought a semi-truck had slammed against the side of the house. We raced outside and found it was just the wind. Another time the wind lifted the topper off our pickup truck and carried it out into the field. We'd planned to put a window on the west side," Jack added. "I'm glad we didn't."

Add some below-zero weather to the frequent winds and most houses would leak energy dollars like a sieve. Not the Winkles'. Thick insulation and a continuous air-vapor barrier keep drafts out and heat in. It shows up in their pocketbook. "Our highest gas bill was $63 for the 30 days from November 21 to December 20 in 1985, which was an extremely cold period. That included water heating, too," Sheryl said. An 83-percent-efficient Carrier natural gas furnace rated at 40,000 Btu supplies most of the heat for the Winkles' house. Electronic ignition replaces the pilot light and saves on fuel. Records from Montana Dakota Utilities show the Winkles average $26 a month for gas—including $12 average for water heating.

An Elko airtight fireplace supplements the gas heat, using about 2 cords of wood annually. Variable speed fans in the plenums built into the rock surrounding the fireplace blow heat out into the family room. Outside air is pulled in through special channels in the chimney to provide the combustion air for the fireplace. If they were to plan their heating system over, the Winkles would make one change. "I'd figure out a better way to circulate the heat downstairs from the fireplace," Jack said. "It gets too hot in the upper living area. If we stoke it up at night, it's too warm for sleeping."

A louvered patio canopy on Jack and Sherry Winkle's house directs sunlight into the house in the winter and deflects it in the summer. The 3,062-square-foot house has fuel costs of less than $200 in gas and 2 cords of wood per year.

Coordinating a fireplace with a Jenn-Air self-venting range in a tight house took some getting used to. "We were warned that in a superinsulated house like this, the fireplace would backdraft if we turned on the Jenn-Air without cracking a window," Sheryl recalled. "Well, one night we did. The Jenn-Air exhausted so much room air that it started pulling outside air down the fireplace chimney. We had smoke everywhere."

Sun Warms People and Plants

During daylight hours, a swinging patio door and two tall windows in the family room gather heat from the winter sun. A concrete slab beneath the carpeting soaks up some of the extra warmth, and insulated draperies keep heat from escaping into the cold night. "We faced

the house just a little east of south for the best solar gain," Jack said.

Jack, an amateur horticulturist, grows a small forest of plants in the warmth of the family room windows. Papayas, figs, and oranges are some of his produce. He's been so successful that he was recently asked by the Indoor Citrus and Rare Fruit Society to write a paper about his methods for coaxing mandarin oranges to fruit. Seedlings of guava, geraniums, mandarin oranges, pine trees, and even orchids are getting their start in the basement. The 8-inch walls and 2-inch rigid insulation on the inside perimeter of the foundation help maintain an even temperature of 68 degrees. Gro-lites furnish the spectrum of light needed by the plants.

A compact, 83-percent-efficient Carrier gas furnace rated at 40,000 Btu takes up little space in the Winkles' basement.

Louvers Direct Sunlight

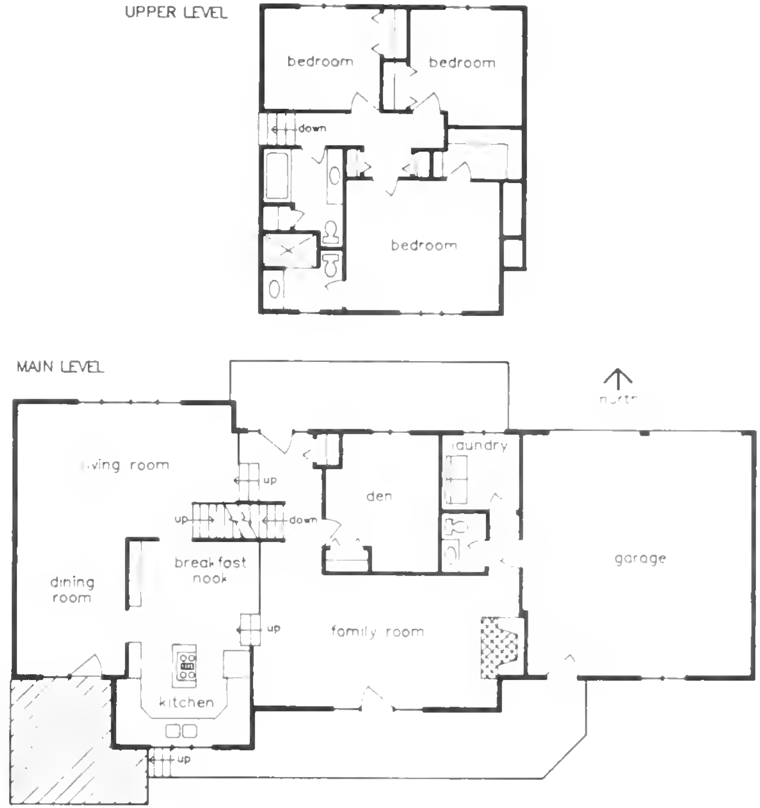
Jack pointed out the wooden louvered patio canopy outside the family room. "That's designed so the louvers will direct the winter sunlight into the house or deflect the summer sun." Within the 12 x 16-foot overhead canopy, twelve 4-foot-square frames hold fixed louvers. By pushing up from below Jack can lift each square out, turn it 180 degrees so the louvers tilt in the opposite direction, and drop the square back into the frame.

In the summer, the heavy insulation keeps the house cool. "We have air conditioning, but we don't need it," Sheryl said. "Last summer we used it two days. We let the evening breezes cool the house, then close it up during the day. We can also use the fireplace fans to pull outside air through channels in the chimney. The stone cools the air on its way into the house."

Ventilation Keeps House Clean and Fresh

A VanEE-2000 heat recovery ventilator brings fresh air into the house, filtering out a lot of dust in the process. About the only upkeep on the ventilator is cleaning the filter—often. "To give you an idea of the amount of dirt floating around," Jack said "people come out from town to scoop up the topsoil that regularly blows into the ditches alongside the roads."

The Winkles recognized early on, however, that the ventilator isn't the answer for all bad air. "One night a skunk sprayed just outside the house," Sheryl said, wincing. "We thought, 'Ah, ha! We'll take care of that,' and turned on the ventilator. Well, that just brought more smell in faster. We had tears running down our faces," she said, laughing. "We quickly shut off the ventilator and opened



the windows to get a cross breeze going."

Sheryl pointed out the dehumidistat control which matches the operation of the ventilator to the weather and conditions in the house. "We thought we'd never figure this out," she said, "but it's second nature now." About the only complaint the Winkles have with the ventilator is the location of a fresh air vent on the staircase wall. Sometimes they can feel the cool air when they are sitting in the living room.

Landscaping for Control

The Winkles also have to deal with groundwater that comes near the surface as a result of irrigating cornfields on bentonite clay. "When the farmers are irrigating in the summer the water table rises, and wet bentonite can put a lot of pressure on the foundation," Jack said. "So the foundation only extends 4 feet below original ground level with a berm rising another 4 feet up the foundation

Drain tiles surround the basement to provide drainage. All the area under the house drains to a sump pump in the basement. Last year the pump hardly ran, so I think the trees we've planted may be taking up some of the moisture. To avoid watering near the house, we terraced the berm and set flowers in the terraces away from the house."

Rapidly growing windbreaks on the west side of the house promise protection in the future. Jack knows what plants work in this country. "Hybrid poplar, buffalo berry shrub, and Siberian pea shrub have turned out to be the best," he said. "Wind dries out conifers." Around the corner, in a more sheltered spot, he's experimenting with hickory and butternut trees.

Why did they build an energy-efficient house? "It was a combination of seeing our utility bills go up over the years, and being impressed with Gordon Aldinger's quality construction," Jack said. He ticked off the energy-saving features of their house: double 2 x 4 wall construction, a 6-mil polyethylene air-vapor barrier on the inside, a spun-bonded polyolefin air barrier on the outside, an insulated basement and garage. "Gordon caulks everything," Jack said, "all the staple holes in the vapor barrier, all the seams. He foams the sills and windows." Light fixtures mounted on the wall instead of the ceiling minimize energy-losing penetrations of the air-vapor barrier.

Sheryl pointed out the bank of oak cabinets in the convenient U-shaped kitchen. "Gordon also puts lots of extras in his houses," she said. "In here I have a pull-down cookbook shelf, an appliance garage, vertical racks for my baking sheets, pull-out shelves in the lower cupboards, and two lazy Susans."

All in all, the Winkles are pleased with their home, although they'd change a few things. "I think people should be able to live in a place about a year, and then go back and build what they really want," Jack said with a laugh. "I'd put a faucet in the basement for my plants. I'd definitely use different siding—stucco, probably. The sun and wind really take their toll on cedar, and so do drips from the outside faucets. We have to oil the siding twice a year; more often where the drips are. But we figure this house will give us long-term savings." □

Family room windows harvest free heat from the sun for the Winkles and their young daughter. Exotic plants flourish in the natural light and warmth of the south-facing windows.

Construction Pays Back

Located on the top of a ridge overlooking Bozeman, Ted and Clara Becker's elegant house unfolds in a series of airy rooms. Banks of windows offer panoramic views of the surrounding mountains. "We could have had a tighter house if we'd had fewer windows," Ted said. "But we compromised for the view. All of our windows are either triple-glazed or double-glazed with low-E film."

Ceilings 11 feet high in the main living areas upstairs recall the Beckers' years in Latin America where Ted was a corporate treasurer with an oil firm. "We like the spacious feeling we get from the high ceilings and I think the large volume gives us good air circulation," Clara said. "In fact, we seldom use the heat recovery ventilator—mainly to exhaust the kitchen, baths, and to remove cigarette smoke. I'm an ex-smoker and I can't stand the smell of it now."

4,328 Square Feet Heated for Less than $400

The insulated windows and heat recovery ventilator in the Becker house are just part of a package of energy-saving features (see accompanying list) designed into the house by Bill Roller. "When the time came to build in Montana, we looked up Roller, who was one of the few builders promoting energy-efficient housing at the time," Ted said. "After touring the Zimmer house, (see the related article on page 47), we contracted with Roller.

From the sunspace on the south side of Ted and Clara Becker's house, a glass door leads to a sheltered deck. On almost any sunny day, the deck collects enough warmth to make it comfortable for use. Below the sunspace, a greenhouse provides fresh tomatoes year-round.

"I figure that in five years the fuel savings will pay back the additional costs of energy-efficient construction," Ted Becker said. "Our highest gas usage was 13,100 cubic feet (at a cost of $44) in December 1985. Since then, we've used between 8,000 and 11,000 cubic feet a month during the winter. Of this, 2,500 cubic feet is for hot water. Our total bill for both gas and electricity from January 1986 to January 1987 was $1,050, of which $400 was for heat."

Sunspace Adds Color and Warmth

The house is designed and oriented for optimum solar gain. A cheery sunspace, profuse with the pinks and whites of begonias, borders the south side of the house with access from both kitchen and living room. More than just a habitat for plants, the room acts as a passive solar collector and provides a sunny green refuge on cold, wintry days.

As the sun rises, the sunspace warms up. "Earlier this morning it was 28

Owners
Ted and Clara Becker

Location
Bozeman

Designer and Builder
Bill Roller
Roller Construction
501 East Peach, Suite A
Bozeman, MT 59715
586-6134

Style
2 Story

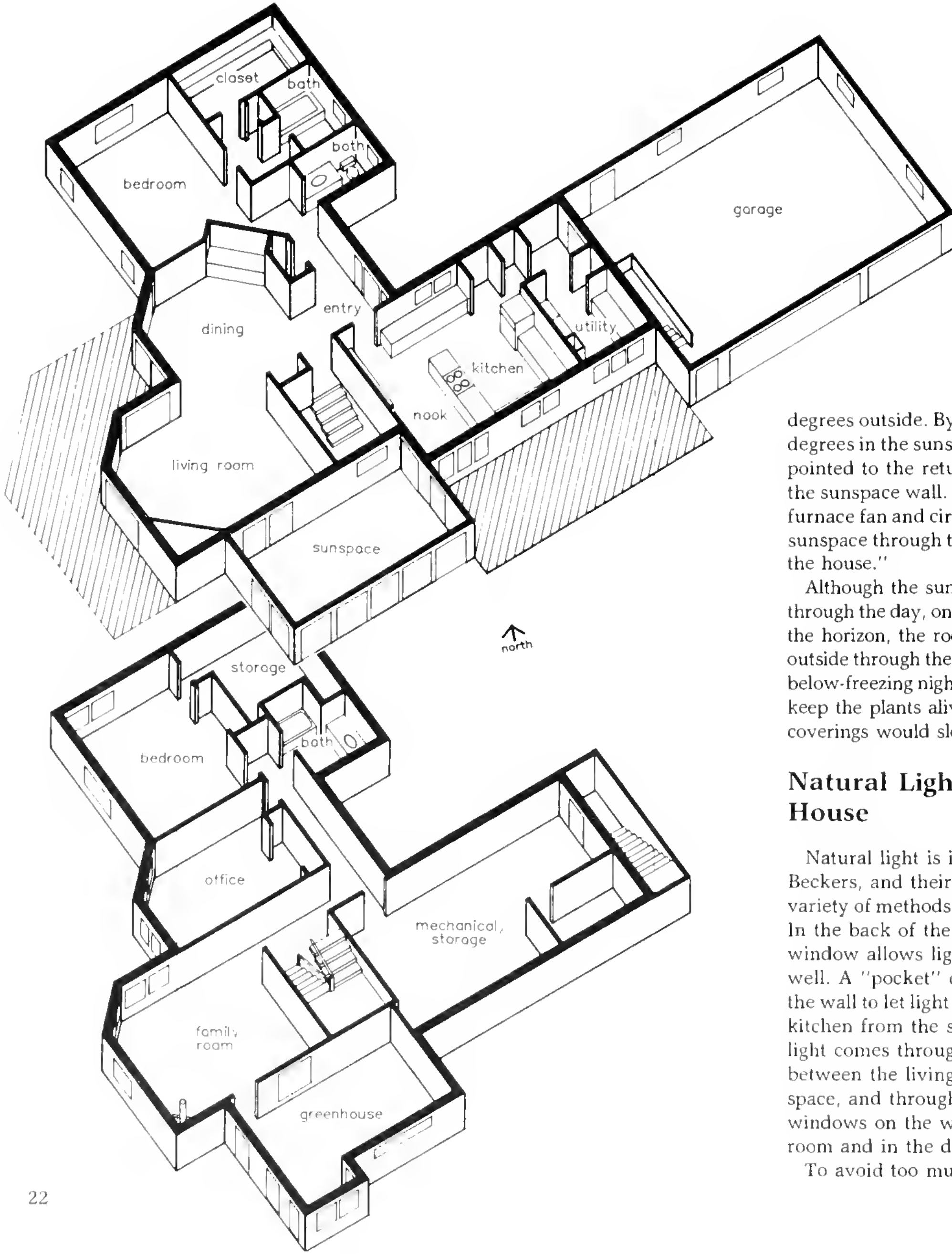
Insulation
Ceiling - R60
Double Wall - R40
Basement Wall - R22
Slab - R5

Square Feet
Main - 2,164
Basement - 2,164

Special Features
Sunspace
Greenhouse
Natural Daylight
Outside Combustion Air
Two Water Heaters

Heat
Passive Solar, Natural Gas, Wood, Electric Baseboard

Completed
Spring 1985



degrees outside. By 10:30 a.m., it was 72 degrees in the sunspace," Ted said. He pointed to the return air vent high on the sunspace wall. "We can turn on the furnace fan and circulate heat from the sunspace through that vent to the rest of the house."

Although the sunspace gains heat through the day, once the sun drops over the horizon, the room loses heat to the outside through the extensive glazing. On below-freezing nights, heat is required to keep the plants alive. Insulated window coverings would slow the heat reversal.

Natural Light Bathes House

Natural light is important to the Beckers, and their design included a variety of methods for bringing it inside. In the back of the sunspace, a large window allows light to enter the stairwell. A "pocket" door slips back into the wall to let light and warmth into the kitchen from the sunspace. More daylight comes through sliding glass doors between the living room and the sunspace, and through floor-to-ceiling windows on the west side of the living room and in the dining room.

To avoid too much sun, Verosol shades with aluminum backing cover the windows. The shades also have an added advantage. "We can see through them," Clara pointed out. A glass door leads from the living room to an expansive deck. "We didn't want a deck railing to interfere with the view," Clara said. "But the building code said we had to have a railing that a child couldn't get through, so we chose tempered glass panels. Actually they weren't much more expensive than wood rails because they don't take as much labor to install. We use that deck a lot on summer mornings. It's on the northwest side and out of the noon sun."

"We should have built a lower roof on the west side," Ted said. "Although the overhang is 10 feet long, it's too high to shade the full length of the windows in the summer."

Downstairs Retreat

The west side of the walk-out basement has plenty of windows to bring in daylight. A family room provides a cozy retreat. Clara gestured to a Kent wood stove sitting on a raised granite slab in the corner. "On a snowy, cold, miserable day, Ted will come down and start a fire. By the time we're ready to go down an hour later to watch the news on T.V., it's delightfully warm. This floor keeps its warmth because of the insulation underneath," she said. Ted added, "The only wood we've used is from building scraps. At the rate we're going, I figure we've got two years left before we run out." Combustion air is piped directly to the wood stove from the outside.

Greenhouse Offers Exercise, Food

A picture window and glass door open the family room to the adjacent green-

A handsome granite fireplace sweeps from floor to the vaulted ceiling of the Becker living room. Air for combustion feeds directly to the firebox from the outside. Sliding glass doors at the left of the fireplace open to the sunspace.

On a wintry day, the Becker's sunspace offers a warm spot for watching wildlife. Elk often graze just on the other side of the fence and a red fox lives nearby. Moose, sage grouse, and weasels also visit periodically.

house. In the greenhouse, a hot tub, exercise equipment, and wood storage share space with potted plants. "Because the hot tub is inside, any heat it loses can be used by the plants," Ted said. An exhaust duct from the heat recovery ventilator carries out excess moisture.

Green indoor-outdoor carpeting brings a continual springtime feeling to the redwood-lined room. Light filters in from a garden window over the hot tub and through the corner window wall. Ted pointed out a Verosol shade covering the skylight over the plants. "The shade keeps the greenhouse from overheating and the filtered light is just right for the plants." He reached over to a bank of pots. "Imagine fresh tomatoes in February in Montana," he exclaimed. "I picked a dozen just yesterday."

An office and guest room share a downstairs bath. A nearby electric hot water heater supplies this bathroom and the two directly upstairs. A second water heater, located in the mechanical room supplies the utility room and kitchen, both of which are located directly above the heater. "By having a separate heater for the bathrooms, we avoid waiting for hot water from the main tank to displace cold water in 40 feet of pipe," Ted noted.

Sizing the Furnace

Ted pointed out the electric baseboard heaters in the downstairs rooms. "We've found those heaters aren't needed. The gas furnace could have heated the whole downstairs as well." But the Beckers had a big job convincing the heating contractor that one gas furnace would be enough, even with the baseboard heaters. "Manufacturers of heating equipment have specifications that aren't scaled for energy-efficient houses," Ted said. "Their tables said we should have a

furnace rated at more than 100,000 Btu per hour.

"One contractor wanted to put in two 60,000 Btu furnaces, one downstairs and one upstairs. That would have been very expensive. Another contractor agreed to put in one 100,000 Btu, 94 percent-efficient gas furnace to serve the main floor and two rooms downstairs, with electric baseboard in the other rooms. Even when it's cold and the wind is blowing, the furnace is just loafing—running for five minutes, then off for ten minutes." The Beckers keep the house at 69 degrees with a 5 degree setback at night.

Construction Features

- Placement for optimal solar gain
- Exterior composed of two 2 x 4 walls, with a 3-inch space between
- Outside wall component framed, and fiberglass batt insulation and 6-mil polyethylene air-vapor barrier applied before interior component framed
- Inside wall component sprayed with 1-inch urethane
- Plumbing and wiring contained in interior wall component so it doesn't penetrate air-vapor barrier
- Ceiling insulated with blown-in cellulose
- Continuous air-vapor barrier in ceiling
- Moisture barrier of 6-mil polyethylene and insulation of 1-inch extruded polystyrene under the basement slab
- Air-vapor barrier of 2-inch urethane foam on rim joist and on all rough openings
- Windows triple-glazed or double-glazed with low-E film
- Insulated exterior doors
- Foam-form-foundation
- Avoidance of building materials that give off formaldehyde fumes

Strategy for Mechanical Equipment

Lots of thought went into the equipment needed to run the house. An electronic filter on the forced air furnace takes out most of the dust before it can settle in the house. "We haven't touched the house since we had 14 people in a week ago," Clara remarked, "and there is absolutely no dust on the furniture." The furnace is a sealed combustion unit.

Of particular concern was their water source. "We're on our own well. We have a softener for domestic water with a bypass for hard water to use on both indoor and outdoor plants," Ted said. "And, if we should have a power outage, although that hasn't occurred, we put in double pressure tanks to keep us going for awhile. Another lesson from past experience is to have an outside entrance to the mechanical room. It makes it convenient for repairmen to get to the equipment."

Heavenly Warmth

How do they feel about the house after living in it for almost three years? "This is sheer heaven. The house is like a big thermos jug—it holds the heat. And the even warmth is much more comfortable than our old house, which had fluctuating temperatures. I don't even need a sweater in the wintertime," Clara said. "It's comfortable both winter and summer," Ted added. "And double wall construction means wide window sills for holding house plants." □

High light-colored ceilings diffuse daylight to all corners of the Becker kitchen. Rounded edges on the countertops of the satin-smooth oak cabinets indicate the attention to detail in the house.

House Wins on Economics, Heating

Construction costs of $43,000, heating costs of less than $200 a year, and a fresh approach to a standard design garnered a Bozeman house a 6-page spread in a national magazine. *Building Ideas*, a publication of *Better Homes & Gardens* awarded Linda Brock and Russ Heliker its Energy-Efficient House Design Award for 1984. According to the second owners, Kathy and Barry Bristow, the house is just as economical and comfortable today.

Split Entry Efficiency

When the husband and wife team of Heliker and Brock combined their expertise as energy consultant and architect to build their ideal house, their first criterion was that it be compact. "A study done in the 1970s showed that size is the biggest predictor of energy use—the larger the house, the larger the energy bill," Russ said. With that in mind, Linda began with a split-entry design, one of the most economical houses to build, and one that makes the most efficient use of space.

The house seems bigger than its square footage would indicate. A "great room" combines living and dining activities into one large area. Half-high walls separate the living space from hallway and entry. The open space above the walls visually enlarges the entire area. Off the kitchen, a closet pantry makes the best use of space without the expense of cabinets.

Economical Heat

A centrally-located Nordic wood stove with an outside air intake serves as the main heat source on the upper floor. "For better circulation we installed the stove in front of an angled wall instead of locating it in a corner which would block radiant heat to the sides," Russ said.

Berming of the first level of the Bristow house on the east, west, and north sides, and to the bottom of the garden windows on the south, directs winds up and over the house and reduces infiltration. The deck faces west, taking advantage of sunny afternoons.

A natural gas standard Heil furnace augments the wood heat. Free sunshine streaming in through a bank of south-facing windows heats the lower level. A sandblasted, exposed concrete wall running through the center of the lower level absorbs heat from the sun and some waste heat from the water heater, dryer, and furnace ducts. "During the three years we lived in the house," Linda said, "the lower level seldom dropped below 60 degrees and never below 50 degrees even on cloudy, subzero days, and without backup heat."

Energy Efficiency on a Budget

"We tried to use fairly conventional building techniques and do something different," Russ explained. "While that's

Owners
Kathy and Barry Bristow

Location
Bozeman

Designer
Linda Brock Architect
Brock Associates

Builder
Russ Heliker
Brock Associates
One West Main
Bozeman, MT 59715
587-0293

Style
Split Entry

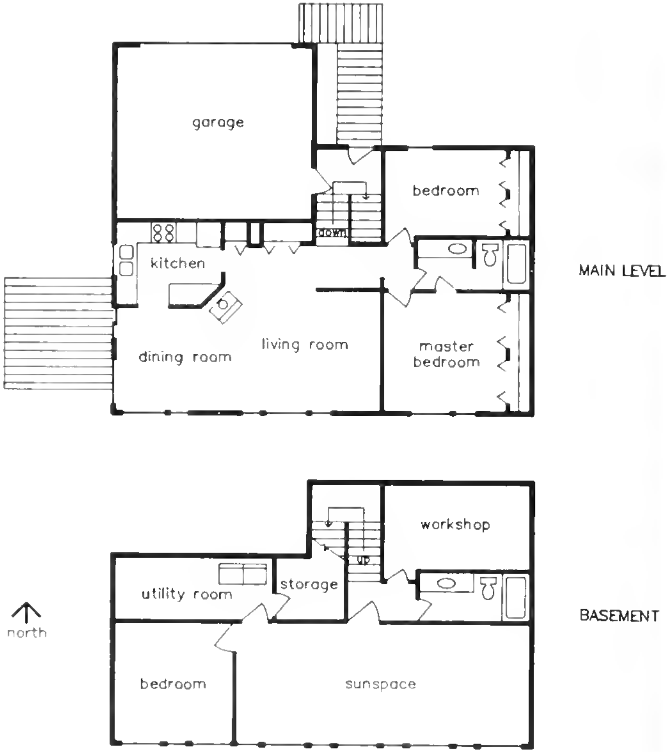
Insulation
Ceiling - R38
2 x 4 Wall - R19
Basement Wall - R19

Square Feet
Main - 1,064
Basement - 1,064

Special Features
Economical Construction
Thermal Storage

Heat
Passive Solar Wood Gas

Completed
1981



easy to do when you have plenty of money, doing it on a budget is another matter."

Their money-saving efforts started with the walls. To add insulation value to the walls without adding substantially to the cost, they sheathed the outside of the conventional walls (2 x 4 stud walls with 3 1/2 inches of fiberglass batt insulation) with 1-inch foil-faced polyisocyanurate foam board. This raised the insulation value from R11 to R19. Duct tape seals the foam board seams. A 4-mil polyethylene air-vapor barrier overlapped at least one full framing space stops air and moisture movement into the ceiling and walls. To save labor, the polyethylene wasn't caulked. The ceiling is filled with blown-in cellulose to R38. Russ and Linda now feel a caulked 6-mil polyethylene air-vapor barrier, an R26 wall, and an R50 ceiling will save enough energy to be cost effective for a house heated with natural gas. They said a house with more expensive electric heat would warrant even more insulation.

One-inch extruded polystyrene foam board was placed between the exterior

A centrally located wood stove augments passive solar heat. Half-walls open the living area to entry, and hallway.

concrete walls and the backfill. On the interior the concrete walls were furred with 2 x 4 studs and insulated with fiberglass batts. "Although we now recommend insulating the basement floor slab, the one in this house is not," Russ commented.

Judicious placement of windows enhances solar heating. Approximately 85 percent of the glazing is on the south, 10 percent on the west, and 5 percent on the north. The windows are actually single pane with a "storm" window mounted inside which Linda and Russ don't recommend. "In high humidity, inside storms allow water vapor around the seam," Russ said. "Today we would use double glazing with a low-E film, or else triple glazing. Those options were very expensive at the time we built this house."

Overhang Tips

Russ had some tips for overhang design so the overhang doesn't shade the sun too early in the spring or too late in the fall. "Lay out the window and roof truss to scale, then draw in the sun angles using an architect's scale. But to be sure, wait to cut off the truss tails until the windows are installed. If you install different size windows than you'd originally planned, the change can really mess up your shading. The same problem results from a last minute change in roof pitch.

"To shade the lower level windows, awnings could be installed. Mobile awnings, although expensive, can be retracted in the winter. Alternatively, awnings can be mounted on a metal frame bolted between the first and second levels."

Grouping the lower level windows together with shared casings makes it possible to install large insulated shades so that few shade edges are exposed

Kathy and Barry Bristow bought the house from Russ and Linda in 1984 They, too, are finding it economical to heat. "The past heating season we used 2 1/2 cords of wood," Kathy remarked. "We don't use the gas furnace; the wood stove and solar heat keep the house very comfortable." □

Rays of the winter sun strike the floor and the center wall of the lower level solarium. The concrete absorbs the heat then slowly releases it as the inside temperature drops.

Windows Take Edge Off Winter

Owners
Greg and Janice Hamley

Location
Bozeman

Designer and Builder
Jonathan C. Jennings
Mountain Home Builders
185 Little Bear Road West
Gallatin Gateway, MT 59730

Style
1 1/2 Story plus Basement

Insulation
Ceiling - R60
2 x 8 Wall - R30
Floor over Crawl Space - R30
Basement Wall - R30
Slab Perimeter- R22

Square Feet
Upper - 530
Main - 1,250
Basement - 640

Special Features
RCDP Construction
Advanced Framing
Sunspace
Trombe Wall

Heat
Passive Solar, Electric Baseboard

Completed
September 1986

In the evenings, Janice Hamley makes dinner in the cozy kitchen of her new house. Over the course of a year, she watches the sun as it moves along its regular schedule, its warm rays falling across the kitchen walls. After years of cold living in drafty trailers and houses, Janice appreciates the friendly sunlight. "The light is really important to me," Janice said, "especially with our long winters. But cold windows aren't very comfortable."

Janice knows about cold windows from experience. The decision to build an energy-efficient house evolved over the 3 years Janice and Greg lived in a chilly and breezy trailer and before and after that when they rented almost equally uncomfortable houses. When it was time to build, they contacted Jonathan Jennings. "Jonathan has been a personal friend for many years," Janice explained. "We knew of his interest in building energy-saving homes, and the type of work he did. It was right up our alley."

Plenty of windows fend off gloomy winter blues in this house south of Bozeman. Built to Residential Construction Demonstration Project specifications, the house incorporates a number of energy-saving features.

RCDP Construction

Jonathan planned a strategy for the home—a tough skin to face the elements, and a strategy to help pay for the extra energy features. He did that by making the house's construction acceptable to the Residential Construction Demonstration Project, a Bonneville Power incentive project to fund energy-saving innovations and technologies in electrically heated houses.

To meet the program's requirement for high-R walls, the house is built with 2 x 8 stud walls on 24-inch centers. The wall cavities are filled with fiberglass batts, and 1-inch polyisocyanurate foam boards were applied to the exterior. A continuous 6-mil polyethylene air-vapor barrier was placed under the drywall, its overlapping seams and penetrations sealed with acoustical sealant.

Advanced framing reduced the amount of nonstructural wood in the house and decreased the potential for conductive heat loss through studs to the outside.

The concrete foundation is waterproofed and clad on the exterior with 2-inch extruded polystyrene. Basement walls are furred out with 2 x 4 walls and insulated with fiberglass batts. A 2-foot-wide border of 3-inch polyisocyanurate foam board insulation lies between the basement slab and an 8-inch gravel base. A 6-mil air-vapor barrier was applied over the polystyrene. In the crawl space, a 6-mil moisture barrier covers the ground, and 9-inch fiberglass batts fit between floor joists.

Sheathed in attractive and durable redwood bevel siding, the house turns its fashionable backside to the street on the north, and faces south to a view of the Hyalite foothills. Placement of the garage shelters the entry and home from winds ripping out of the northwest and buffers

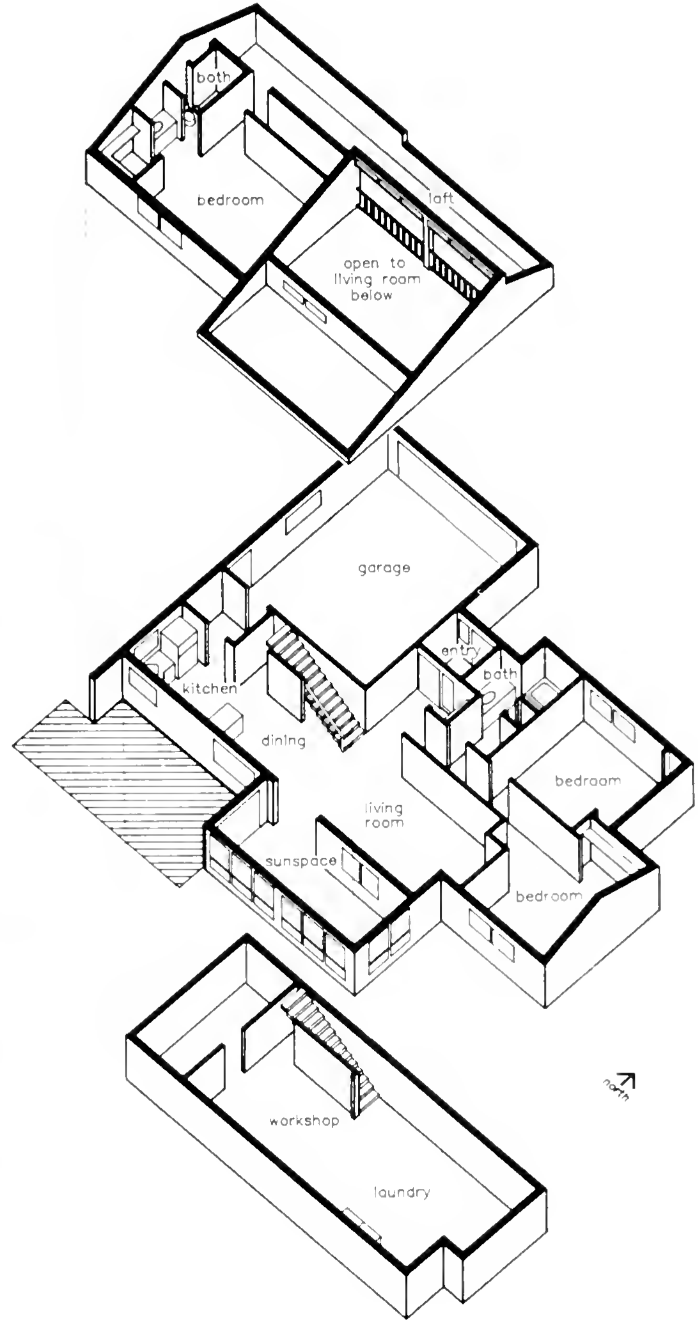
the Hamleys from street noise. The garage also serves as a tempered shelter and entry for the Hamley's large dog. An airlock vestibule brings guests in from the cold without sacrificing heat to the outdoors.

Special Wall Stores Heat

Other components contribute to the energy efficiency and comfort of the Hamley home. A sunspace collects heat and light. Concrete stores the heat. One side of the living room is an 8-inch-thick Trombe wall, textured and painted white just like the other walls. The Trombe wall rises 21 feet from foundation to the top of the second story.

"People expect a Trombe wall to be warm," the builder said. "In actuality, the temperature runs between 60 and 90 degrees which, considering the average temperature of the human hand, feels cool to the touch. But it's certainly warmer than the outdoors in winter and releases warmth as the house cools down in the evening."

A sunspace on the south side of the house is one of Greg and Janice Hamley's favorite spots for reading, having morning coffee, or playing with their young son. Transom windows above the French doors in the Trombe wall help regulate the admission of heat to the living room.



A window relieves the monolithic solidity of the Trombe wall and affords a view from the living room to Hyalite Creek and the trees bordering the creek at the edge of the property. Glazed ceramic tile covers the concrete floor of the sunspace, its copper color adding visual warmth.

By opening the sunspace's French doors and transom windows, the Hamleys control the heat flow from the sunspace into the living area. "It really works," Greg said. "If the sun is shining and everything is opened up, we don't need the electric heat."

All windows are Pella double glazed with low-E film. Although the Hamleys haven't installed insulated window coverings yet, they said the coverings would help hold the heat. The overhang, carefully sized for the windows, blocks the hot rays of the summer sun.

Circulating the Air

A VanEE-2000 heat recovery ventilator continuously wafts warmed fresh air into the house and expels the stale. A small electric heater in the ductwork ensures that the air is warm enough to avoid unwanted cool drafts.

Greg pointed out the ceiling fan which also stirs the air. "I can really feel the difference when I turn it on," he said. "It draws the heat down in the winter and moves it out in the summer."

Tracking Kilowatts

For the 12-month period beginning November 1986 Hamley's total kilowatt-hour (kWh) usage was 16,169 or $790 at an average rate of $0.049 per kWh. In February 1987 meters were installed to separately track electricity usage for space heating, water heating, and other uses. From February 10 to April 29, the Hamleys averaged 103 kWh per week for space heat and 145 kWh per week for water heating.

Janice said they are very pleased with the performance of the house. "I'm not aware of the air temperature in this house, which means it must be comfortable," she added. "We also are comfortable at lower temperatures because we have no drafts."

Building Energy Efficiently

Janice said people ask her if it's more difficult to build an energy-efficient home. "Absolutely not," she exclaimed. "Of course, having someone build any home for you deflects a lot of the anguish you'd have building it yourself. About the only things we had to deal with were the same things we'd have to deal with in any house—picking colors, floor coverings, and so forth."

To build a home of this size and style, Jonathan Jennings estimates the cost at $50 a square foot, not including lot, septic system, well, or utility hookups. □

Diffuse north light shines through clerestory windows above the loft (top left of photo), while warm southern rays pour in through the sunspace.

Two large windows over the kitchen sink bring in the warm winter sun. The windows swivel from the center so both sides can be cleaned from inside the house.

Old World Charm, New Techniques

Outlined against the sharp, snowy peaks of the Bridger and Gallatin mountains, Wally and Mary Hansen's house might be sitting on a hillside in Switzerland. Exposed roof trusses on the 4-foot gable roof overhang, a long sloping roof, and suspended decks bestow a style reminiscent of alpine chalets.

Wally designed the house to fit into the natural beauty of the site. The house's low profile hugs the ground. A bermed patio area around the southwest corner shelters the front entry. Broad eaves built into the expansive roof are sized to allow maximum winter sun penetration while providing shade from the summer sun. At the back a sunken garden patio offers a retreat where a recirculating waterfall splashes into a small pool in the summer.

Living room, dining area, and kitchen flow into one another, sharing space and light. Vaulted ceilings, an open loft, and white walls emphasize the feeling of spaciousness. From the west gable, daylight streams into the house through two tiers of glass crowned by a Palladian half-round window.

The deep dining room window sills nurture flats of seedlings in the spring and geraniums and begonias later in the season. Behind the kitchen sink and range, teal blue accent tile borders the oak backsplash beneath the European-style kitchen cabinets.

The sequestered master bedroom and bath ensures privacy and a view of the stars. Above the bed and over the whirlpool bath, Velux roof windows embedded in the south-sloping roof bring the Montana sky inside. Adjacent to the bedroom, a roomy sitting area in the loft overlooks the living room.

Exposed trusses give Wally and Mary Hansen's house a look reminiscent of alpine chalets. The truss style allows room for plenty of insulation in the ceiling. A detached two-car garage and bermed patio shelter the entryway from cold winds.

The lower level opens onto a sunken garden patio. Windows on the south and east sides open the basement to light and heat from the sun.

Economy of Labor and Materials

The Hansen house design is more than decorative; it emphasizes energy-efficiency with a minimum of labor and materials. As one of the pioneering architects at the National Center for Appropriate Technology in Butte in the early 1970s, Wally researched building techniques that would save people the most energy while still affording an enjoyable place to live. Now, with help from the Residential Standards Demonstration Program, he was putting that knowledge to work for his family.

Owners
Wally and Mary Hansen

Location
Bozeman

Designer
C. W. Hansen, Architect
P.O. Box 41
40 East Main, No. 6
Bozeman, MT 59715
587-9514

Builder
Harry Annear Construction
P.O. Box 394
Bozeman, MT 59715
587-7804
and Owner-Architect

Style
1 1/2 Story with Walk-Out Basement

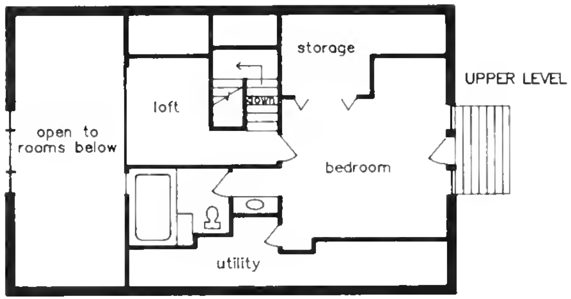
Insulation
Ceiling - R60
Double Wall - R38
Basement Wall - R19
Slab - R10

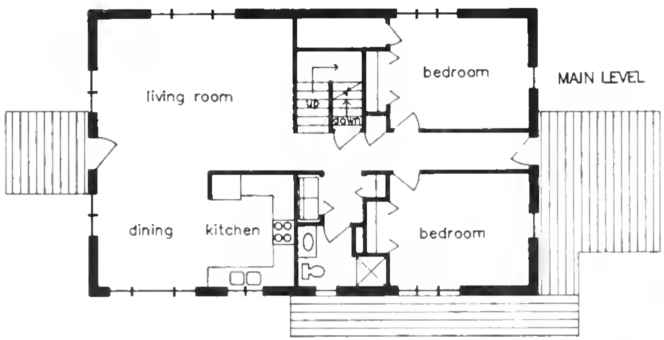
Square Feet
Upper - 669
Main - 1,232
Basement - 1,232

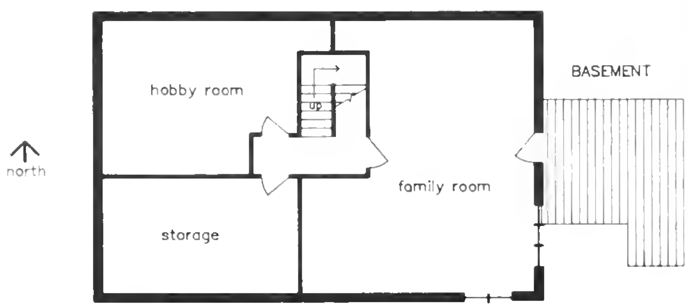
Special Features
RSDP Construction
Exposed Roof Trusses
Air Quality Monitoring
Economy of Construction

Heat
Electric Baseboard

Completed
February 1985







Wally described the construction that met the RSDP guidelines. "The trusses afford plenty of room for a loft without the need for second floor sidewalls," Wally said. "And by using this truss system, we didn't have to resort to on-site framing to get sufficient insulation in the vaulted ceiling."

The 20-inch depth of the roof trusses accommodates 18 inches of blown fiberglass. Baffles maintain a 2-inch ventilation path from soffits to the attic. "The continuous ridge vent is one of the best ways to vent an attic and is a nice way to finish off the ridge," Wally said.

Based on his extensive research, Wally built 11-inch walls using two 2 x 4 stud walls, each insulated with 5 1/2-inch fiberglass batts. "This type of wall is most cost effective, especially for people planning to do their own insulating," he said. "Installing fiberglass batts properly requires some knowledge, but doesn't require a separate subcontractor with all kinds of specialized equipment." The air-vapor barrier was placed directly under the drywall. Electrical outlets were set in special polyethylene boxes to which the air-vapor barrier was sealed. To ensure the integrity of the air-vapor barrier between floor levels, 1-inch polyisocyanurate rigid board was installed and carefully caulked with Tremco acoustical sealant.

The basement slab was insulated with 2 inches of extruded polystyrene foam board over a 6-mil polyethylene moisture barrier. The basement was furred out with 2 x 6 studs and the cavities packed with R19 fiberglass batts.

House Openings

Placement of triple-glazed clad casement windows maximizes solar gain in winter and cross-ventilation cooling in summer. "Although our view of the Bridger Range to the north was

Two gable windows and a door leading from the bedroom to a deck admit early morning east light. Winter sunlight enters the three south-facing roof windows.

The open floor plan promotes air circulation and a feeling of spaciousness.

To gain access to a large deck overlooking the garden at the rear of the house, a gallery replete with plants and paintings leads from the living area past two bedrooms, a bath, and utility area

important we kept that glazing to a minimum," Wally said. The north windows consist of one in the living room, one in a bedroom, and a roof window over the stairwell. Metal cladding on the exterior window frames ensures easy maintenance. Insulated steel exterior doors are magnetically weatherstripped to ensure a tight seal.

Air Quality

To maintain air quality and a comfortable humidity in the house, a VanEE-R2000 heat recovery ventilator brings in fresh air and expels the stale air when 47 percent humidity is exceeded, or when switched on from the bathrooms or kitchen. Both the ventilator and hot water heater are located behind the knee wall, an easily accessible, heated portion of the house, and do not impinge upon any usable floor area. This location minimizes duct runs and helps to maximize air flow from the heat exchanger. Supply outlets were carefully placed so occupants don't feel any draft from the incoming fresh air.

To answer questions on air quality in tight houses, the RSDP installed monitors in all program homes to track radon and formaldehyde levels the first year. Readings of 2 picocuries per litre for radon were well below the acceptable level of 5. The difference between the first formaldehyde sample and the second sample a few months later reflected some initial emission of formaldehyde fumes from the new construction materials. However, the level of 0.1 part per million met the standards the Department of Energy considers acceptable.

The Kilowatt Difference

Does the house perform? From April of 1985 to April of 1986, Wally and Mary used just 6,812 kilowatt-hours (kWh) of electricity for space heating (2.17 kWh per square foot per year). At the current rate of \$0.053 per kWh this amounts to about \$360 a year. To show it in perspective, space heating for RSDP homes over all averaged 2.59 kWh per square foot per year. Homes built to HUD standards average 6.58 or \$1,087 in space heating costs per year. The extra cost of \$5,420 for construction above HUD standards to meet the RSDP specifications should be paid back in a little over seven years at today's utility rates.

Conserving Energy is a Lifestyle

But saving energy entails more than just building a superinsulated house. "Lifestyles and individual philosophies remain as the most important ingredients," Wally said. "To effectively use an energy-efficient house takes a new way of thinking. For instance, we have friends who live in a log cabin with wood heat. When it's zero degrees outside, they come into this house and automatically look for the hot spot—the radiant heat from a wood stove—for immediate gratification. That's not how an energy-efficient system works. These tight homes have a totally controlled indoor environment which includes air quality, humidity, and heat, eliminating any need for a hot spot."

An Affordable Plan

"The straightforward design and construction techniques allow this type of home to be built within a moderate price range," Wally said. "Evidence of this is the several speculation houses built and sold in the Bozeman area based upon this design and using these construction methods. Site arrangements and slight plan adjustments have been made, but the comfort and satisfaction with the energy-conserving performance remains the same in all cases." □

No Drafts

Owners
George and Vera Hoadley

Location
Bozeman

Designer and Builder
Bill Roller
Roller Construction, Inc.
501 East Peach Street, Suite A
Bozeman, MT 59715
586-6134

Style
1 Story with Basement

Insulation
Ceiling - R60
Double Wall - R32
Basement Wall - R22
Slab - R5

Square Feet
Main - 1,676
Basement - 1,676

Special Features
RSDP Construction
Foam-Form-Foundation

Heat
Electric Hot Water Baseboard

Completed
January 1985

On a quiet street just a short stroll from downtown Bozeman, George and Vera Hoadley's brick and frame house gives no outward indication that it's built any differently than its neighbors. About the only tip-off is windowsills wide enough to hold large potted plants. The 9 1/2-inch-deep windowsills are the result of double wall construction. Two thicknesses of fiberglass batts fit in the double 2 x 4 stud walls. A raised truss ceiling allows room for an 18 1/2-inch layer of Silvawool from one outside edge of the house to the other. A 6-mil polyethylene air-vapor barrier was installed on the exterior-facing side of the interior stud wall and between the gypsum board and framing in the ceiling. A fully insulated basement provides additional warm space. But let George talk about the basement.

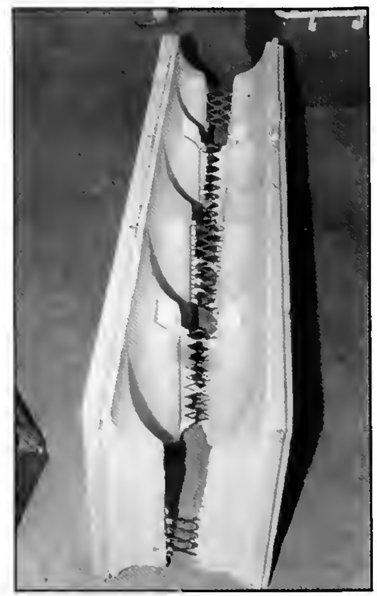
Foam Forms for the Basement

"Finished the way it is, as long as there's any heat in the house at all, the basement would never freeze, even when it's 40 below outside," George said. "Here's how Bill (Bill Roller, the builder) does it. He uses foam panels instead of wooden forms when he pours the concrete for the basement walls. He pours the footings, then builds the wall forms with these foam panels. Their edges are tongue and groove so they fit tightly together. Rebar is installed in the conventional manner and big wood clamps hold the forms straight while the concrete is poured."

Bill Roller says the foam forms, made of 2-inch thick extruded polystyrene, are big savers of time and material. Cumbersome wooden forms aren't needed and the foam remains in place to insulate the walls to R22. "We can do a basement in about one-fourth the time it would take to construct one using wooden forms and to sheath it with foam after the concrete has hardened," Bill said.

To complete the basement, the walls were furred out and covered with dry-

Energy-efficient features keep George and Vera Hoadley's 3,352-square-foot-house draft-free and comfortable for about $50 a month.

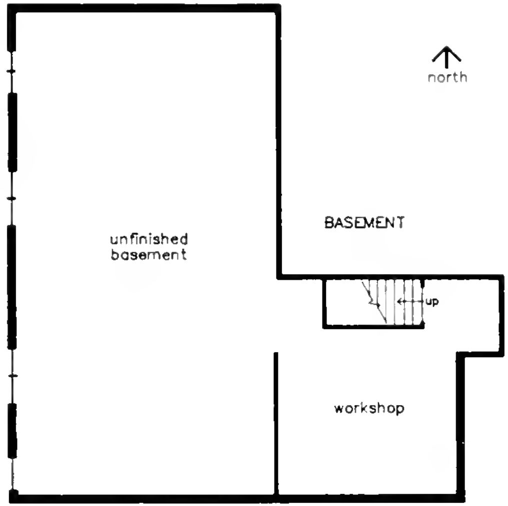


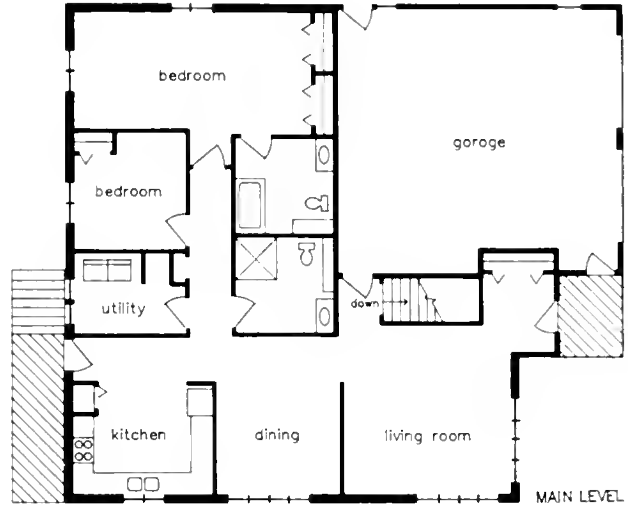
Foam panels stack to make concrete wall forms which are left in place for their insulating value.

wall. Under the 4-inch-thick concrete slab, a 4-inch layer of washed rock, a 6-mil polyethylene moisture barrier, and 1 inch of extruded polystyrene insulation prevent the loss of interior heat through the basement floor.

Draft-free Living

A comfortable basement is a necessity for George, who spends a lot of time downstairs repairing small engines. For Vera, a draft-free living space is important. "Just a little bit of breeze in the house and I'm chilled through and through," she said. "I think the double walls keep the temperature from fluctuating. One of the things we use the ventilator for is to freshen the air when it gets too stuffy. That's better for me than opening doors or windows. I also use the ventilator when I burn something cooking or fry fish," she said, chuckling. "We don't have to worry about odors," George added.





Insulated flexible ducts carrying fresh air make an S-curve on the heat recovery ventilator (ducts shown on the left of the unit). The gradual curve is part of the strategy to keep the ventilator whisper quiet. Its basement location keeps duct runs short and straight to the rooms above, and makes the ventilator accessible for regular filter changing.

The heat recovery ventilator automatically turns on if the humidity increases to more than 40 percent. "It rarely runs, though," George said. "When it gets colder outside, I lower the humidity level a bit. We've never had any condensation on the windows."

The air is warmed by sunlight that enters windows on the southwest corner of the house. Triple-glazed Andersen Permashield windows keep heat from escaping when night falls. Zero-maintenance steel siding and brick help conserve George's energy. "My neighbors are quite envious. When they paint, I can play," he said. "The siding is guaranteed for 40 years. I told the distributor that it probably would outlast me," he added with a grin.

Heat by Hot Water

The Hoadleys liked the even heat provided by the gas-fired hot water heating system in their previous house, and they wanted a similar system in their new house. They opted for hot water baseboard heat. The water is heated by electricity and each baseboard unit is individually controlled. Except for the bedroom and the basement, the temperatures are kept around 74 degrees. From March 1985 to March 1986, the Hoadleys used 11,844 kWh for space heating, or about $50 a month.

To build a house similar to the Hoadleys' would cost about $95,000, not including land or site improvements. The energy extras for the double-wall construction, heat recovery ventilator, air-vapor barrier, and triple glazing cost about $5,500.

A Comfortable House

How did the Hoadleys learn about energy-efficient living? "We just wanted a nice, warm, comfortable place to live," George said. "Our son had seen some of Bill Roller's work and said he wouldn't have a house built unless Bill did the work So Bill did the work. He submitted our house for the Residential Construction Demonstration Program and it was accepted. We didn't know too much about the program, but feel we've benefitted from the construction."

"I went to a home show here in Bozeman," Vera said. "There was a fellow there exhibiting insulation, and when I told him about our house he said, 'If Bill Roller built you a house, you don't need any insulation.' He's right. This is a very good house, very comfortable." □

Home Buyers Stumble Across Energy Efficiency

Owners
Merlin and Anna Jones

Location
Bozeman

Designer and Builder
Jim Baerg
1900 Nelson Road
Bozeman, MT 59715
586-6813

Style
Split Level

Insulation
Ceiling - R60
Double Wall - R42
2 x 6 Upper Wall - R27
Floor - R19
Crawl Space Walls - R15
Basement Stem Walls - R10
Basement Pony Walls - R23
Slab Perimeter - R10

Square Feet
Upper - 832
Main - 648
Basement - 832

Special Features
RSDP Construction
Insulated Window Shades

Heat
Passive Solar, Electric Baseboard

Completed
August 1984

Checking the real estate section of the Sunday paper and then roaming through the advertised open houses provides enjoyment for many Montanans on lazy weekends. Anna and Merlin Jones had taken many such tours when they stumbled across a special house in Mountain View Subdivision near the little town of Belgrade. "Although we weren't particularly looking for an energy-efficient house," Anna said, "we simply got hooked on it." After living in this house for three years, they remain enthusiastic about its features.

Superinsulation and winter sun pouring in through 89 square feet of south-facing windows add up to tiny heat bills for Merlin and Anna Jones. Their home near Belgrade is one of 67 in Montana built to the specifications of the Residential Standards Demonstration Program sponsored by Bonneville Power Administration in 1984.

Proper Orientation Pulls in Sun

The house faces a few degrees west of south, to make the best use of the sun. "On a clear day in the winter, I open the living room shades in the morning and the heat just pours in," Anna said. "If I leave the door to the sewing room open, I can heat the upstairs simply from the sun coming in through those windows. Most houses in this neighborhood aren't designed to take advantage of the sun. It's really too bad."

"One of the things I like best is that the house stays clean," Anna said. "I dust about every three or four weeks. In fact, I washed off the plants last summer. After six months they still aren't dusty." Anna attributes the cleanliness to the tight construction, the heat recovery ventilator, and the lack of a wood stove.

Perspectives on Wood Heating

Merlin, who keeps the boilers working at Montana State University, talked about switching from their old house heated with wood to their new one heated with electricity. "Our other house was usually too hot," he said. "This is even heat and, I think, healthier because we're not continually breathing wood smoke. Besides, I can't cut wood for what it costs me in electricity here, and I don't want the mess in this house.

"If we were to get another wood stove, I'd install it in the basement. It also would be a stove specially made to burn wood pellets. I converted the wood stove in the last house to burn pellets."

Less Than $200 for Electric Heat

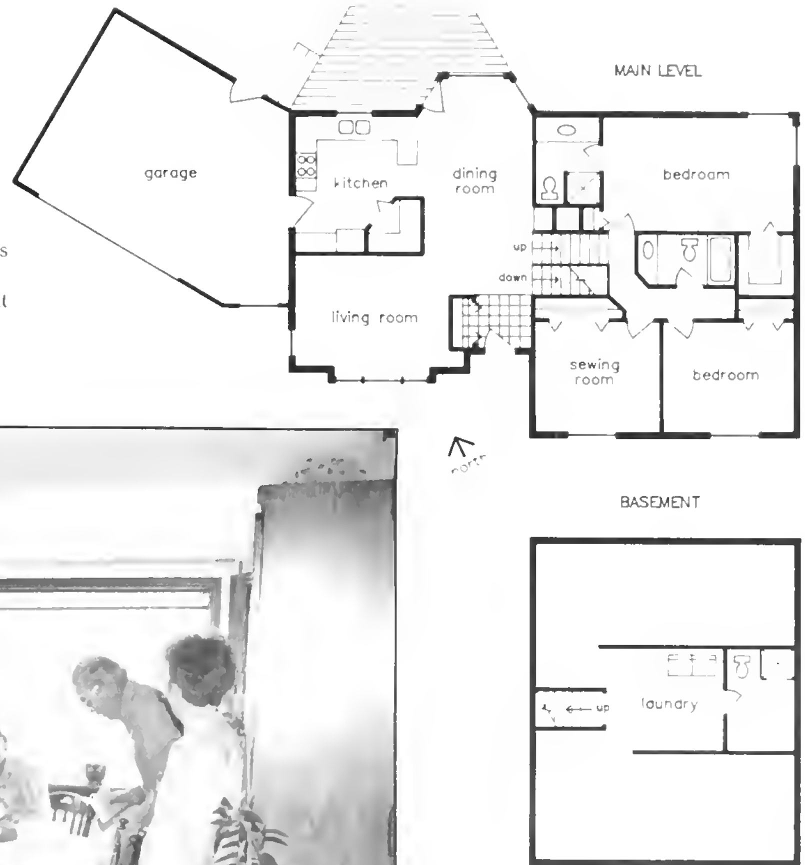
Although Anna and Merlin keep their house at a constant 70 degrees during the day with an automatic setback at night to 60 degrees, their usage is low. "Our friends say, 'What you pay in a year for heat, we pay in a month,'" Anna said, with a laugh. "But, it's true." She laid out the heating bills for the past

heating season. Based on a rate of just over 5 cents per kilowatt hour, this is what they paid

September	$ 0.00
October	11.00
November	36.07
December	38 17
January	48.51
February	28.69
March	27.42
April	4 54
May	2.10

The total heating cost for the year was $196.50. Merlin and Anna were able to identify their costs for space heating because the house was built under the Residential Standards Demonstration Program which requires installation of a submeter that tracks kilowatts used for space heating.

Besides the home's even heat and cleanliness, Merlin said they also enjoy its quiet "We can't even hear the train across the way," he said. Anna added that



The dining area extends a few feet out on the north of the house opening the room to a view of the Bridger Range and plenty of natural light. An insulated door offers convenient access from the dining area to a large deck and yard Seated at the table is builder Jim Baerg, who discusses aspects of the house with Merlin and Anna Jones.

Suspended fluorescent lights illuminate the kitchen. This efficient light source sheds the maximum amount of light for watts used, and the suspended fixtures eliminate the need for penetrations of the ceiling air-vapor barrier.

when their 5 1/2 year old granddaughter came to visit, she said, "Grandma, this house is weird, you can't hear anything."

RSDP Construction

The home gains its comfort from the thick insulation and tight construction the builder used when he built the house to the specifications of the Residential Standards Demonstration Program. Raised heel energy trusses left room in the attic for R60 fiberglass insulation to the edge of the outside walls. Double thickness walls on the north, east, and west contain two R19 fiberglass batts. The 2 x 6 stud wall on the south contains one R19 batt. The walls are sheathed on the exterior with 1-inch polyisocyanurate foam board. A 6-mil continuous air-vapor barrier was installed on all exterior walls and the ceiling before the drywall was hung.

The main living area is built over a crawl space with R19 batts in the floor above the crawl space. Three-inch extruded polystyrene insulates the inside of the three exterior crawl space walls. A 6-mil polystyrene moisture barrier covers the ground in the crawl space and runs up over the insulated crawl space walls to the rim joists.

On the interior of the common wall between the crawl space and the basement, 2 x 6 framing contains R19 fiberglass batts. Two-inch extruded polystyrene sheathes the exterior of the other three basement stem walls. The 2 x 6 framed portions of the basement walls are insulated with R19 fiberglass batts and sheathed on the exterior with 3/4-inch polyisocyanurate foam board. A continuous 6-mil air-vapor barrier was installed under the drywall in all walls. A 2-foot-wide border of 3-inch extruded polystyrene insulates the outer area of the slab. A moisture barrier of 6-mil polyethylene lies over a 4-inch gravel base.

According to DNRC records, building the house to meet RSDP specifications cost about $2.90 a square foot more than houses built to HUD standards. This included additional framing and insulation, an air-vapor barrier, a heat recovery ventilator, and extra glazing. Jim Baer, the builder, estimated the cost to build a similar house would be $45 to $50 per square foot.

Added Attractions

Although energy savings played a big factor in Merlin and Anna's decision to buy the house, other custom features attracted them. The mellow grain of oak in the floor of the entry, window casings, moldings, and balusters accents the creamy beige carpeting of the living room and hall. European cabinets and ivory and beige striped wallpaper contribute a fresh, sleek look to the kitchen. Location of the coffee maker, mixer, toaster, and other appliances in the pantry leaves kitchen countertops uncluttered and ready for food preparation.

Anna surveyed the living area. "About the only major change I can think of would be to add clean-up facilities in the garage to keep mud and dirt out of the house. All in all, the home suits us just fine." □

Double-glazed Pozzi windows and insulated Window Quilts minimize heat loss to the outside during sunless hours. Air circulates to the entry and kitchen over the short walls separating them from the living room.

Builder Sells Home Owner on Energy Efficiency

In February of 1982, Kenny and Karen Kempt happened upon Bill Roller demonstrating energy-efficient house construction at the Bozeman Winter Fair. "I'd already picked a builder for my house," Kenny said, "but Bill kept touting energy-efficiency. He finally convinced me, and I was a hard one to convince. We've never been sorry.

"Bill is a perfectionist," Kenny said. "He caulked every crack, every staple in the vapor barrier. He sprayed urethane foam around the windows. He put a double bead of caulking between floor plates and gasketing under sole plates and sill plates. His carpenters literally framed the house with a caulking gun handy in their hip pockets."

Brick and Tile Absorb Sun's Heat

Located northwest of Bozeman, the Kempt's stylish house looks out on the driving range of the Riverside Golf Course. Mountains can be seen from every window: the Bridgers, Spanish Peaks, Tobacco Roots, and Hyalites.

But the setting provides more than a view. The home faces a little west of south so that rooms on the south side of the house soak up heat from the low rays of the winter sun. On the north wall of the family room, floor-to-ceiling brick stores the heat from the sunlight streaming through the two-story windows across the room. In summer, the overhang blocks most of the sun and the window coverings do the rest. "The house stays comfortable year-round," Kenny said.

Steeply-pitched rooflines at each end of Karen and Kenny Kempt's house lend more than style. On the west, the extra-high ceilings allow more south window space for solar heating in the vaulted family room. On the east, the elevated roof and basement allows for two levels of private space.

On the north side of the house, windows are either recessed or protected by vertical box beams to keep the wind from blowing across the triple-glazed windows and pulling the heat out. A sheltered porch and airlock vestibule keep outside chill from entering when exterior doors open.

Owners
Kenny and Karen Kempt

Location
Bozeman

Designer and Builder
Bill Roller
Roller Construction, Inc.
501 East Peach, Suite A
Bozeman, MT 59715
586-6134

Style
1 1/2 Story

Insulation
Ceiling - R60
Double Walls - R44
Slab - R5

Square Feet
Upper - 1,024
Main - 1,824
Basement - 224

Special Features
Thermal Storage
Wall Temperature Sensors

Heat
Electric Radiant Ceiling Panels

Completed
June 1983

The brick wall also encloses a woodstove. Kenny said they could probably do without it. "We've only burned about half a cord of wood in the three years we've been here," he said. "I just don't like the mess or the smell."

In the centrally-located dining room, bronze-colored quarry tile covers the concrete slab. During the day, the tile and concrete collect and store the sun's heat, and at night release that heat to the surrounding rooms. Quadruple window panes with low-E film and insulated draperies retain the heat after the sun drops from view.

The tile floor continues through the kitchen where tall windows and two skylights allow sunlight into the corner breakfast area. Kenny motioned to a beveled leaded-glass insert adjacent to the atrium patio door "That glass came from my mother's house. Bill sandwiched the single pane between two pieces of regular 3/16-inch glass, making it a tri-pane."

Hidden Details Contribute to Comfort

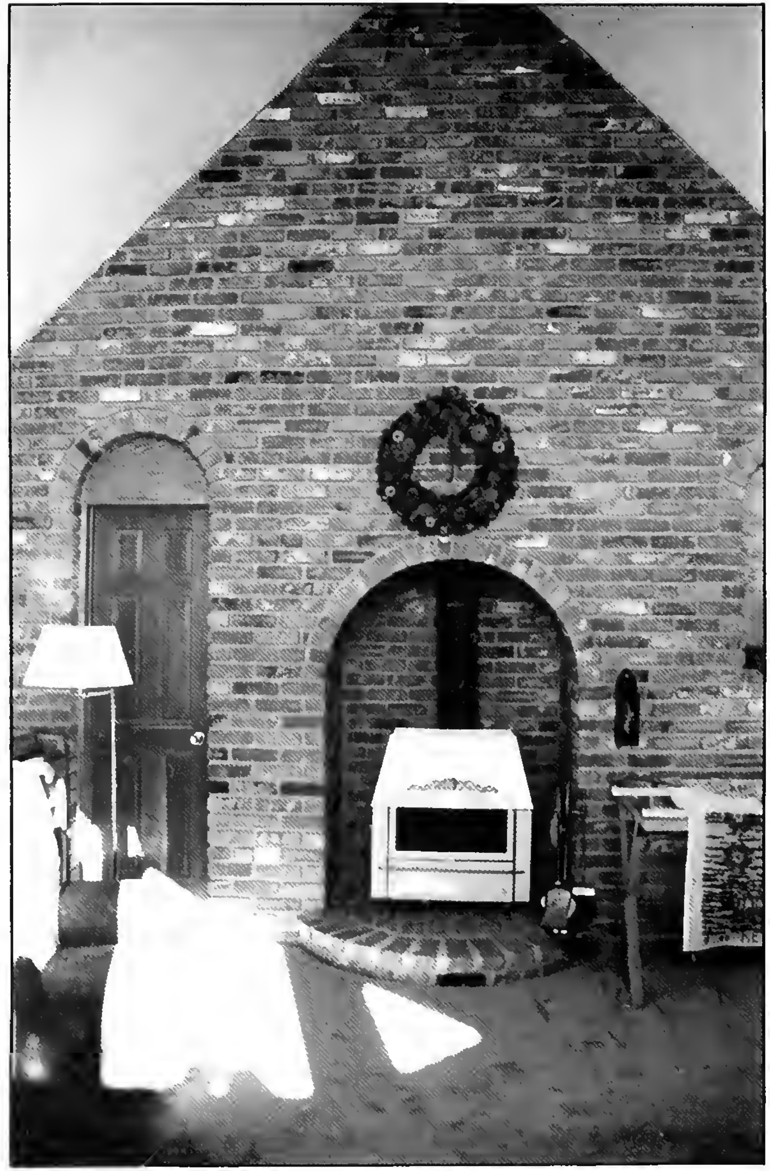
Superinsulation and negligible air infiltration also contribute to the home's energy savings. The double walls are 10 inches thick and packed with two layers of fiberglass batts. The inner portion of the wall is lined with 2 inches of urethane foam and a 6-mil air-vapor barrier. The wall is sheathed with polyisocyanurate foam board. The ceilings are filled with blown-in cellulose. To slow heat loss to the ground, the 4-inch foundation slab rests on 1-inch extruded polystyrene foam board. Six-mil polyethylene provides a moisture barrier under the insulation. Extruded polystyrene foam board covers foundation walls from footings to sill plate.

Kenny led the way up a half-flight of stairs to the luxurious master bedroom and bath. He pulled open the door to the attic storage. "This is a specially built door. It's even insulated."

A combined utility, office, and exercise room occupy the lowest level four steps down from the main living area. Garden windows introduce plenty of natural light into the cheery utility area. Kenny pointed out the laundry chute and central vacuum system. "Talk about energy saving," he said, "those two items certainly do their part for people."

Air and Moisture Control Made Easier

To learn more about the performance of double wall construction in this part of Montana, the builder, Bill Roller, installed six temperature sensors at 1-inch intervals from interior to exterior in the north wall. "The information helped us understand how heat is transferred in a wall," Roller said. "Our data showed that so long as the outer wall was two-thirds or more thicker than the inner wall of the double wall, we could put the continuous air-vapor barrier behind the insulation of the inside wall without condensation forming on the air-vapor barrier. This meant we could put all wiring and plumbing in the interior wall and avoid penetrating the air-vapor barrier. This reduces the amount of caulking needed to seal the air-vapor barrier and makes construction more energy efficient and more affordable."



Winter sunshine creeps across the Kempt's family room. The heat from the sun will be absorbed by the brick and released at night as the house cools. At the left of the stove a door leads to a wood storage area which can be filled from the outside.

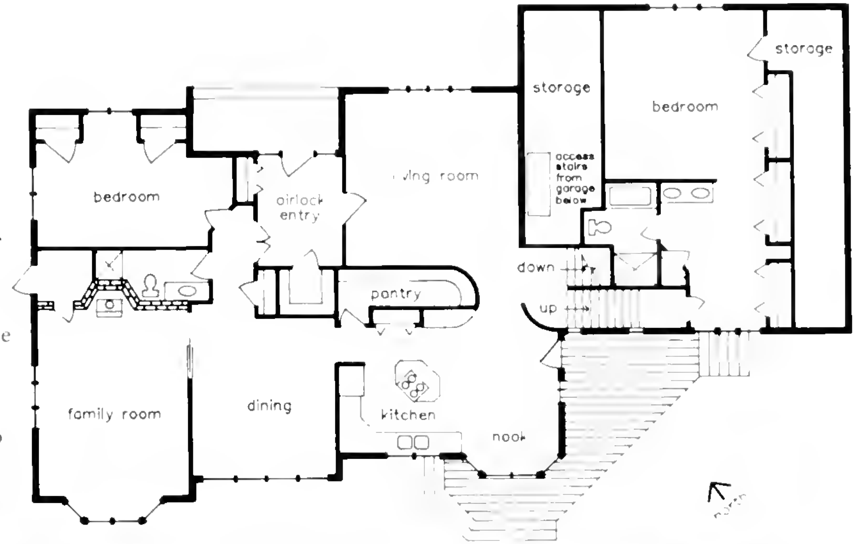
The Kempts don't have a central heat recovery ventilation system. Instead, they opted for a wall-mounted Mitsubishi heat-exchanger to control conditions in the master bedroom-bath area. "We thought that if humidity was a problem, we'd install a central ventilation system later," Kenny said. "The first year the moisture was a bit excessive, but it's decreased now to where the temperature has to drop below zero for minor condensation to form at the bottom of the windows."

Even Heat From Radiant Ceiling Panels

In the ceiling, 8-foot electric heating panels pick up the heating job when the sun shuts off. "We chose electric heat because it's clean and quiet and even," Kenny said. "By installing ceiling panels we don't have to worry about draperies hanging over baseboard heaters. And we have a panel and thermostat for each room, so we only heat the rooms we need."

"Our first winter in this house, our highest monthly electric bill was $165, which seemed a bit high. Then we checked with our neighbors who have a conventional house the same size and found theirs was $325, so we felt pretty good. Since then, the bill has gone as high as $219 a month, but the rates have gone up, too."

Is this house different from their previous house? "Absolutely," Kenny said. "It's much quieter, and the heat is so even. In the evening it's a smooth transition from solar to electric, no noisy blowers, no pipes popping." □



To keep penetrations of the vapor barrier to a minimum, the Kempts installed an Emerson electrostatic air purifier above the island cooktop that removes odors and grease without being vented to the outside. The purifier's filter can be cleaned in the dishwasher.

Large windows bring winter sunlight into the dining room. A tiled concrete floor stores the sun's heat.

Warm Floors and Fresh Air Delight Home Owner

Owner
Vivian Linden

Location
Bozeman

Designer
Owner

Builder
Dave Wesen
Boone & Crockett Construction
P O Box 3744
Bozeman, MT 59715
388-1880

Style
2 Story, Daylight Basement

Insulation
Ceiling - R50
2 x 6 Wall - R40
Basement Wall - R21
Slab - R10

Square Feet
Main - 948
Basement - 896

Special Features
RCDP Construction

Heat
Electric Radiant Ceiling Panels and Baseboard

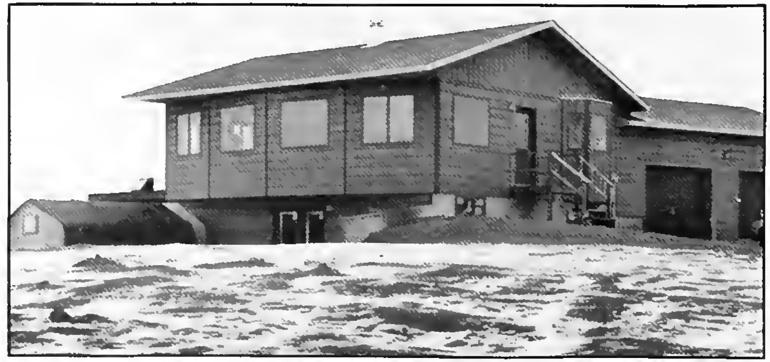
Completed
September 1986

Last year Vivian Linden burned wood for heat and still paid more for electricity than she did this year for a totally electric house of twice the size. "I look forward to getting my utility bills now," she said. "It costs me from $60 to $70 for all my heat during the winter. For the month of March I used just 324 kilowatt-hours." At the rate of $0.052 a kilowatt-hour, that means a $16.85 heat bill for March. Vivian said the energy-efficient water heater costs approximately $9.00 a month in electricity.

On acreage west of Bozeman, Vivian resides with Rover, her very independent black cat. For nine months of the year she teaches sixth grade math and science; for the other three she wrangles horses and cattle on a ranch near Quake Lake. Having worked with energy education for a long time (she serves on the state energy education committee), Vivian knew what kind of house she wanted and the type of space she needed, so she drew up her own house plans.

Solar Heat Aids Green Thumb

In the living room, the rounded south wall catches the eye with its bank of four large windows. All windows are Andersen double glazed with low-E film. Dave Wesen (the builder) said they are specially built for altitudes over 4,500 feet, which means reduced gas pressure inside the glass to make a clearer pane



Energy-saving construction includes prefinished siding and vinyl clad windows in Vivian Linden's house west of Bozeman. The only exterior painting required is on the corner trim and fascia board.

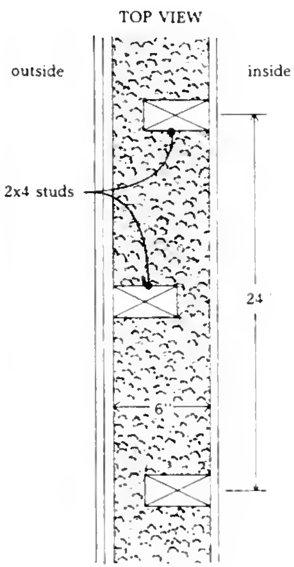
On the upper level of the Linden house, electric radiant panels, concealed in the ceiling drywall, augment solar heat pouring in through the large band of south-facing windows.

and prevent pressure breakage, and have a 20-year guarantee.

In the spring, light from these windows nurture potting plant seedlings. Fifty or more seedling pots sit on tables in front of the windows, tiny green plants poking their heads above the soil. The windows also provide the home's solar heat gain. "I haven't had the heat on since the first of April," Vivian said. "If the sun shines, I get heat, even when the outside temperature is zero or less. On January 25th it was 40 degrees and sunny. I didn't turn the heat on and it was still 68 degrees in here." Even with all the plants, humidity isn't a problem.

For someone who enjoys gardening, a greenhouse is almost a necessity in southwestern Montana. Vivian's greenhouse is next to the west end of the walk-out basement's south wall. The greenhouse is the one thing she'd do differently. "I'd include it as part of the house's structure so I'd have direct access to the doors in winter." On the north side of the basement, a root cellar stores produce.

Staggered Stud Wall

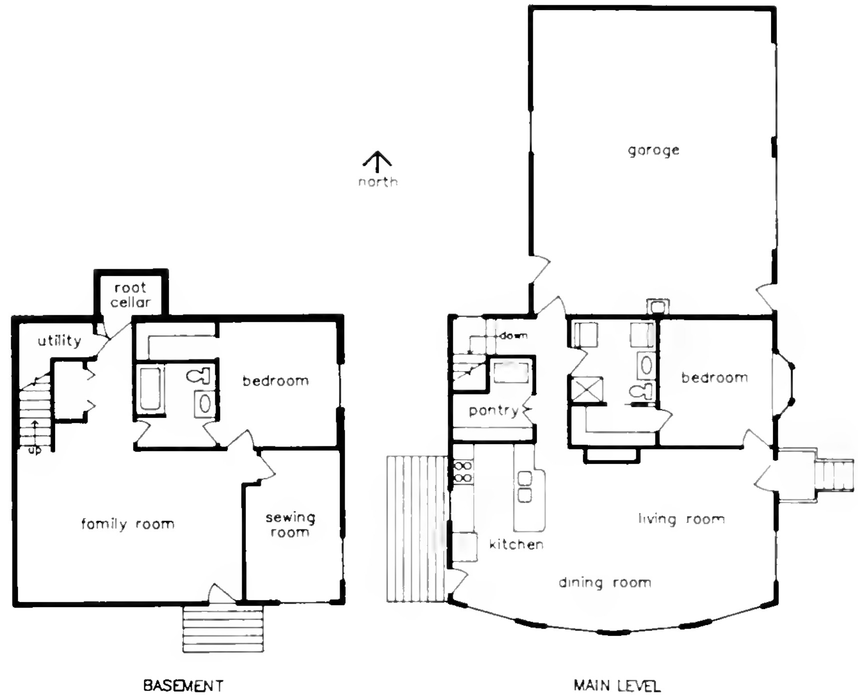


Insulation Also Acts As Air-Vapor Barrier

Dave Wesen, who built the house under the Residential Construction Demonstration Project (RCDP), attributes the low cost of insulating the house to his own brand of single wall construction, which he says is as effective as double-wall construction. "It cost $4,200 to insulate the whole house, including the slab, the basement walls, the upstairs walls, and the entire ceiling. I don't think any double-walled house can be built as tight as this one for the money. And I've built more than half a dozen homes with double-wall construction and air-vapor barriers."

Dave's technique is to use 6-inch-wide top and bottom plates. He staggers 2 x 4 studs on 24-inch centers, placing one stud on the outside wall, the next stud on the inside, and so forth (see diagram). Staggering the studs prevents thermal bridging. He foams layers of urethane into the wall cavity to a 5 1/2-inch thickness, resulting in an R-value of 40. The urethane serves both as an air-vapor barrier and insulation. In the ceiling 1 1/2-inch-thick urethane is covered by blown-in fiberglass batts (Insulsafe-III). The urethane in the ceiling also serves as the ceiling air-vapor barrier.

Beneath the basement slab, 2-inch extruded polystyrene over a 6-mil polyethylene moisture barrier rests on a



6-inch layer of packed gravel. On the interior of the concrete basement walls, a 2 x 4 stud wall contains foamed-in-place urethane. All the walls of the house are finished with drywall.

"When DNRC conducted the blower door test," Dave said, "the only leaky spot that showed up was a hole where a piece of plywood flooring was poorly glued. I drilled and caulked it, which stopped the leak."

Vivian appreciates the VanEE-2000 heat recovery ventilator. "I'm a nut for fresh air," she said. "With the ventilator, I don't have to open the windows and let in the dust and cold air."

Although it costs a bit more to build energy efficiency into a house, Vivian says it's well worth it. "Moving here from my mobile home makes me feel like I've gone to heaven," she said. "I can run barefoot upstairs or down and the floors are toasty warm. There isn't one cold spot in the entire house."

To build a similar house, excluding the lot and utility improvements, would cost approximately $31 per square foot, Dave estimates. "As time goes on and utility rates rise, we're going to find that these efficient houses will be in demand." □

RSDP Helps Owner-Architect Design and Build for Montana Mountains

Owners
Shaila and Henry Sorenson

Location
Bozeman

Designer
Henry Sorenson

Builder
Mike Christophersen
P O Box 991
Belgrade, MT 59714
388-4611

Style
2 Story

Insulation
Ceiling - R38
Double Wall - R35
Basement Wall - R18
Slab - R5

Square Feet
Upper - 686
Lower - 896

Special Features
RSDP Construction
Greenhouse
Thermal Storage

Heat
Passive Solar, Electric Baseboard, Wood

Completed
October 1984

Rumors of monthly $350 heating bills in the area where they planned to build spurred Shaila and Henry Sorenson to examine energy-efficient housing. "We had just moved from Florida, where houses are designed to keep the sun out. Here we had to design to capture the sun," Shaila said.

Through his teaching position in the School of Architecture at Montana State University, Henry heard about the Residential Standards Demonstration Program (RSDP). He designed the house to meet RSDP specifications and the house was built to comply with the requirements of the program. Shaila and Henry are now spending less money to stay warm than they did to stay cool.

Construction Combines Techniques

Shaila, who also is an architect, talked about the construction. "Before we built, we checked different techniques for making the house energy efficient, including active and passive solar, earth sheltering, and superinsulation. We combined several of those methods."

The home's lower level is embedded 4 feet in the ground. The 4-inch concrete slab was poured over a 6-mil moisture barrier covering 1-inch extruded polystyrene, underlain by a 4-inch gravel base. The concrete walls of the basement are insulated with 1-inch extruded polystyrene on the outside and 2 x 4 stud walls with R13 fiberglass batts on the inside.

Two-story windows in Shaila and Henry Sorenson's house capture a view and heat from the winter sun. Roof overhangs shade the windows in summer.

Double walls frame the upper level. Each of the two 2 x 4 walls in the double wall contains R13 batts. One inch of expanded polystyrene between the walls adds insulating value and acts as a thermal barrier between the studs. Polyisocyanurate sheathing on the exterior brings the total wall R-value to 35. Six-mil polyethylene beneath the drywall forms an air-vapor barrier. Tyvek beneath the siding and around the rim joists further tightens the house against air infiltration.

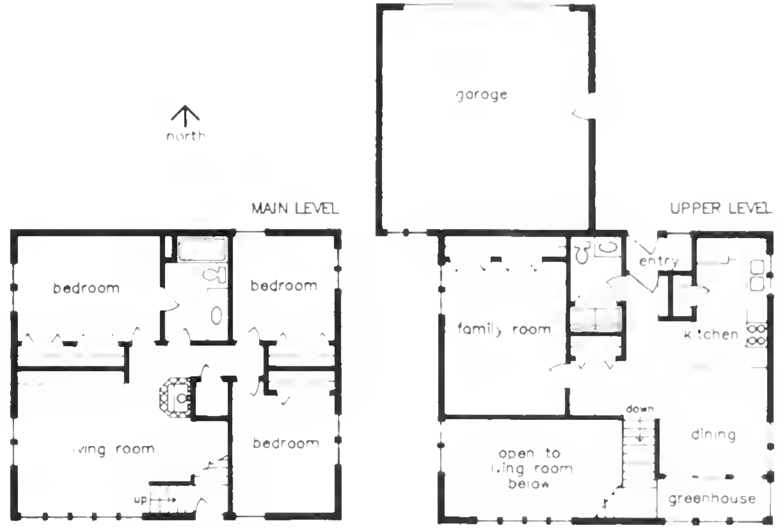
High energy roof trusses allow room for 12 inches of blown-in fiberglass in the attic. The ceiling has a 6-mil polyethylene air-vapor barrier. To keep the insulation bone dry, continuous soffit vents and four ridge vents carry moisture up and out of the attic.

To minimize heat loss through windows the Sorensons installed only 2 windows on the north side and used triple glazing. Overhangs on the south shade the windows from direct summer sunlight, helping to cool the house

An E-Z-Vent 210 heat recovery ventilator keeps the air fresh. We do get some condensation in the downstairs bedroom next to the bath, but we don t run the ventilator continuously because I don t like the fan noise," Shaila said

Space Heat Less Than $200 A Year

The energy-efficient design works According to RSDP records, the Sorensons used less than 3,000 kilowatt hours from April 1985 to April 1986 for space heating. At a rate of $0.042 per kWh, that amounts to $126 for a year's worth of heating. Although a wood stove supplements the heat with 1/2 cord of wood a year, the biggest auxiliary heat source is the sun



Heat from the greenhouse pours into the dining area through sliding doors.

The extended roofline shelters both front and back entries

To collect free heat on Bozeman's many clear days, Henry faced the house for optimum solar gain and designed thermal storage into the structure. Winter sun streams through double-decker windows in the two-story-high living room. A handsome floor of exposed aggregate concrete absorbs the extra heat, releasing it at night when the house cools.

On the second level, a small greenhouse off the dining room acts as a solar collector. "When our son was an infant, he was very sensitive to changes in temperature," Shaila said. "I'd put him in the greenhouse to sleep where it stayed warm."

Composite Design

The Sorenson's house, sitting atop a high hill with panoramic views, is a composite of features the Sorensons admired in other plans. On the upper level an airlock vestibule at the north entry has a bench to sit on when pulling on snowboots, with hooks for hanging bulky clothing. Muddy clothes and shoes can go directly to the utility room/half-bath just around the corner.

A convenient U-shaped kitchen opens to the dining area. Sliding doors can be opened to admit heat from the greenhouse. Shaila pointed out the wood strips on the vaulted ceiling. "That's T-1-11 paneling, which looks like tongue-and-groove cedar but is considerably cheaper." Adjacent to the kitchen, a loft is occupied by the TV-lounge room which looks into the living room below.

The lower level houses the living room, three bedrooms, and a large bath. The open plan encourages air circulation and allows rooms to share views and space.

The Payoff

The various additions required to meet RSDP specifications, including materials and labor for more-than-normal insulation, triple glazing, a heat recovery ventilator, air-vapor barrier, and so forth, cost about $6,000, or approximately 8 percent of the total building costs.

With heating bills of less than $200 a year compared to the over $1,000 they suspect they would have spent without the energy features, the Sorensons calculate the payback should be within five to seven years. In the meantime, they enjoy the view of the snow-capped Bridger and Tobacco Root mountains while their windows admit free heat from the winter sun and their superinsulated house keeps it in. □

Heat from the winter sun streaming in through south-facing windows (left) is absorbed by the concrete floor of the living room. Two west-facing windows and light-colored walls balance the natural lighting, illuminating all corners of the living area.

Big House is Easily Heated

A stately cedar and stone house presides from a ridge looking over Bozeman. The substantial expanse of windows makes it seem unlikely that this house is energy-efficient. But it is. "Tell people," Sarah Zimmer said, "This this house is easy to heat, and that we never have a cold room."

The secret to miserly heating bills is found in the home's construction: triple glazing, a continuous air-vapor barrier, insulated double walls, a thick layer of attic insulation, and insulated basement walls and slab. "The only place you can feel any air infiltration is along the sliding glass door in the kitchen," Sarah said. "But Bill Roller, our builder, warned us that a sliding glass door wouldn't be tight."

The construction of the Zimmer house is similar to that of the Kempt house (see the related story on page 39). When Lew Zimmer was shopping for houses in Bozeman, he saw the Kempt house. It looked a lot like what they wanted, with some changes.

Lew and Sarah Zimmer's house is placed so that the living room, dining room, kitchen, and family rooms look out on the Spanish Peaks and Tobacco Root mountains. The long overhang and deck protect most of the west-facing windows from summer sun. Window coverings shade the rest.

A garage beneath the cathedral-roofed studio (right side) on the north buffers the Zimmer house from wintry winds and shelters the recessed entry.

One of those changes was to install wood and gas heating systems along with electric heaters. The Zimmers burn an average of 6 cords of wood a year and pay $3.00 to $5.00 a month for gas heat in the 7,500-square-foot house. The bedrooms and bath upstairs have electric wall heaters. "The heaters aren't used much because the upstairs gets a lot of heat from the rising warm air," Sarah noted.

Enjoying Wood Heat

The Zimmers use wood for most of their heat. "We're outdoor people, and we enjoy gathering and chopping wood," Sarah said. Ninety percent of their wood heat is delivered from an airtight stove on the lower level. A blower on the stove circulates heat through the first level, and a register with fan placed in the floor above the basement draws heat to the upstairs.

Owners
Lew and Sarah Zimmer

Location
Bozeman

Designer
Zimmer-Roller Revision of
Stock Plan from
Home Magazine Ltd

Builder
Roller Construction, Inc.
501 East Peach, Suite A
Bozeman, MT 59715
586-6134

Style
2 Story with Walk-out Basement

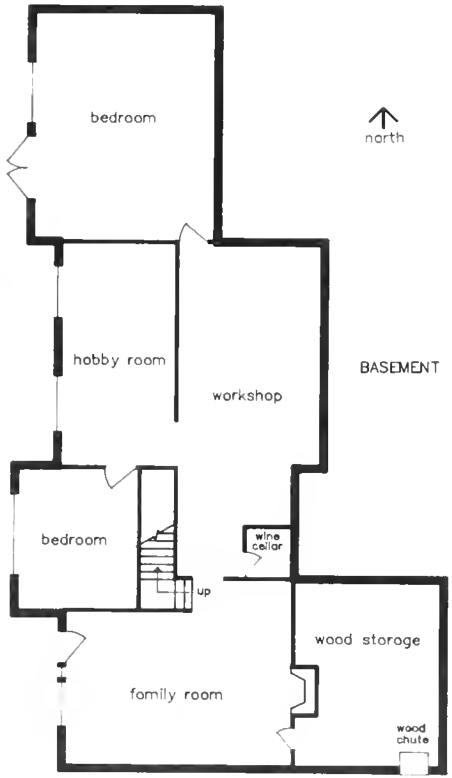
Insulation
Ceiling - R60
Double Wall - R32
Basement Wall - R22
Slab - R4

Square Feet
Upper - 1,400
Main - 2,700
Basement - 2,700

Special Features
Sunroom
Solar Preheated Hot Water
Outside Combustion Air

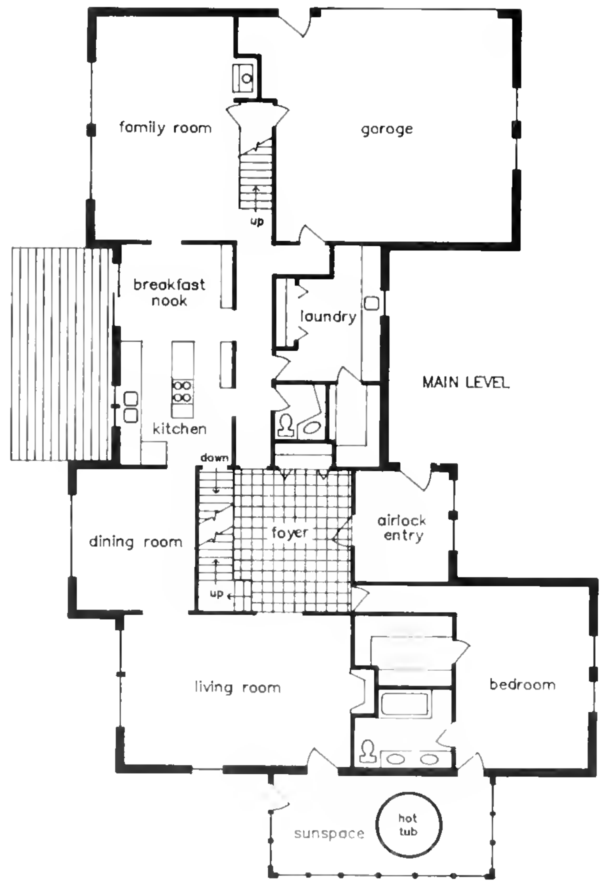
Heat
Wood, Natural Gas, Electricity

Completed
1983

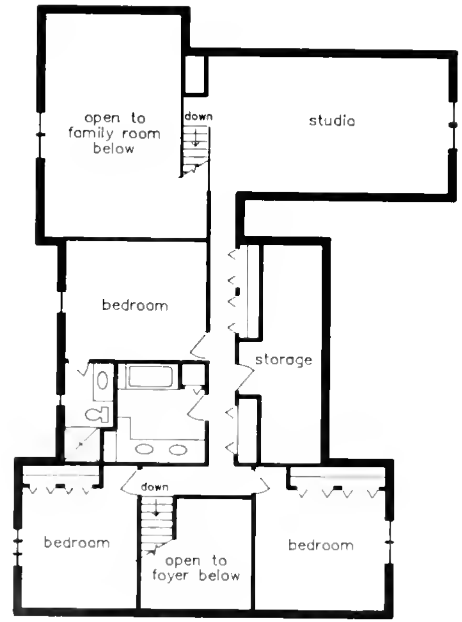


north

BASEMENT



MAIN LEVEL



Sarah pointed out the wood storage in an adjoining room. "It's easy to get wood in here because we allowed for a 3- x 4-foot entry in the foundation, and fitted a chute to the window well. We simply throw our wood down the chute from the driveway above."

A stove recessed in a ceiling-high stone wall in the vaulted family room is a second source of radiant wood heat. A staircase rises adjacent to the stove. Sarah opened a door in the staircase wall to reveal a neatly stacked wood pile. "This is accessible from the garage, which keeps the wood splinters out of the carpeting," Sarah said. "About the only thing I would do differently," she said, "is to set the stove in front of the stone wall rather than within it, so more heat would radiate into the room." On clear winter days, the stone wall does double duty. The rays of the sun stream through opposing two-story windows and warm the stone, which releases the heat as the house cools off.

Gas Pulse Supplements Wood

Two gas pulse furnaces supplement the wood heat. "We've found we don't need both furnaces," Sarah said. "The heating contractor thought the duct runs from one furnace would be too long and too small to deliver enough heat. But once the heat is delivered to a room, it doesn't leave." Because of the low temperature of the exhaust, the furnaces vent through PVC pipe out through the wall under the deck, eliminating the need for a chimney through the roof.

Combustion air is delivered directly from the outside to the combustion chambers of the furnaces and wood stoves.

Sun Plays a Part

A sunspace on the south side of the house gathers free heat and affords a comfortable spot for a hot tub. During the course of a day, the sun pours first through the east-facing windows in the sunspace, then the south-facing windows, and finally through the west windows. The sun also is tapped to preheat water. A coil embedded in the floor of the sunroom

While snow covers the ground outside, the sunspace proves just right for soaking up the heat pouring in through the windows

carries water to the hot water tank. Water on its way to the water heater picks up heat from the sun-warmed concrete.

Upstairs Designed for Air Circulation

Two staircases, one from the family room and one from the foyer, lead to a large, vaulted studio, the children's bedrooms, and a bath. The open stairways and a corridor running the length of the second story promote air circulation between the two upper floors. Sarah pointed out the open transoms over the bedroom doors, which allow air circulation to the rooms even when the doors are shut.

"Bill was very fussy about putting openings through the ceiling vapor barrier," Sarah said, "so we eliminated the two skylights we planned for the bath and one of the bedrooms up here. The bath has no windows to the outside, but the lack of natural light in here hasn't bothered us." She also said they chose an electric water heater to avoid installing a vent through the ceiling.

A Favorable Experience

The Zimmers have nothing but praise for the energy-efficient construction and performance of their house. "Our original plan was from a stock plan in a magazine," Sarah said. "After we saw the Kempt house, we had Bill Roller design the energy-saving features into the house. Then we got three bids from contractors wanting to build the house," Sarah said. "All of them were willing to do the energy-efficient construction, but Bill promoted it more than the others. We have no regrets. It was a very favorable building experience." □

Double doors leading from a foyer to an airlock entry are closed in the winter to stop heat from rushing out when the front door is opened. The foyer leads to the upstairs master bedroom, central hallways, and living room. A door from the living room (right center in the picture) opens to admit heat from the sunspace.

A Family Tradition of Saving Energy

Owners
Tom and Verna Jo Brewer

Location
Broadus

Designer
Owners and Jim Goodwin, Architect
South of Sheridan
Sheridan, WY 82842

Builder
Owners

Style
3 Levels, Underground

Insulation
Roof - R20
Front Wall - R19
Below-grade Concrete Walls - R10

Square Feet
Upper - 450
Main - 1,200
Basement - 450

Special Features
Underground

Heat
Passive Solar, Wood, Electric Baseboard

Completed
January 1985

When Tom and Verna Jo Brewer of Broadus decided to build a new house, they made energy efficiency a top priority. Verna Jo's father, Albert Pikkula, had experimented extensively with various applications of solar power at his home nearby. He was using passive solar sunspaces with liquid-filled containers to store solar heat long before high energy prices made energy conservation popular.

Partly on the basis of Mr. Pikkula's efforts, the Brewers decided to build an underground house with passive solar adaptations. They had an ideal location for such a house: a high, south-facing bank of gumbo on their property just outside Broadus. This gumbo proved harder than expected, and blasting was necessary to dig the hole.


The Brewer house, backed into the gumbo just outside Broadus.

Fitting into the Surroundings

The Brewers designed the house themselves with the assistance of Jim Goodwin, an architect from Sheridan, Wyoming. The house is built on three levels, with a total of about 2,100 square feet of living space and a 14 x 24 garage on the east end. On the outside, the structure blends harmoniously into its surroundings. Dropping down from the front of the house, terraces rip-rapped with native sandstone increase the eye appeal.

The south side of the structure faces about 14 degrees west of due south, because that was the orientation of the bank the house is built into. The roof overhang prevents entry of direct sunlight during the summer months. Verna Jo said that the house tends to be cooler in March than in January because the outside temperatures in March are fairly low and the sun is at a high enough angle to be largely blocked by the overhang.

Electric Heaters Not Needed

Next to the sun, the most important heat source for the house is a large Blaze King wood stove. This stove normally burns about 3 cords of cottonwood each winter. Electric baseboard heaters were installed to provide any additional heat necessary, but these have not been turned on since shortly after the Brewers moved in.

Natural Light

The front entrance leads directly into a large room that is flooded with natural light from the bank of south-facing windows, even when the overhang prevents entry of direct sunlight. The

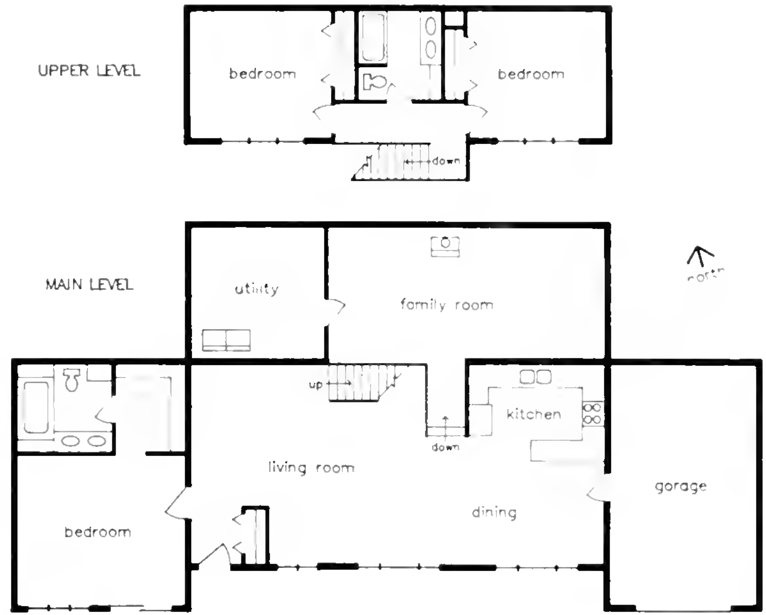
floor in this room is mostly carpeted, but with quarry tile along the area next to the windows. Sunlight warms the tile in the winter, and the heat thus stored helps warm the living space after the sun has set and temperatures start to drop. The kitchen in the northeast corner of this room receives plenty of indirect natural light during most of the day.

Thoughtful Design

The two bedrooms used by the children are upstairs with a bathroom between them. The stairs leading to the second story are designed to present an opening so the parents can see into the children's bedrooms from the main floor. If the Brewers were building the house today they would alter the design to make visual access to the upstairs bedrooms even more open, so they could see the children from a wider area of the main floor.

The lowest level of the house is reached by descending two steps from the main floor. This lowest level is in the rear of the building and is partially taken up by a family room. The wood-burning stove is located in the family room against the north wall of the house. The laundry room and a storage area take up the remainder of the space on this level.

The interior surfaces of the concrete walls are finished with drywall mud applied directly to the concrete and painted. There is no visible hint that the walls are concrete. An interesting con-



Sun through the south windows heats the Brewer house and stores solar heat in the floor tile.

struction feature in the living room is the rectangular recesses that were formed into the concrete to allow placement of pictures or wall hangings.

Plenty of Concrete

As with most houses of this type, the roof and outer wall structure is concrete. Side walls and the rear wall are all 12-inch reinforced concrete, for the first 8 feet up from the footings, then 8-inch concrete above that. The front wall with its many sun-collecting windows is a single 2 x 6 studwall with R19 fiberglass insulation. Concrete walls were insulated on the exterior with a single thickness of 2-inch extruded polystyrene extending down to the footings.

The upper level roof is 8-inch reinforced concrete, and the lower is 10-inch. The roof is supported at midspan by four 5-inch support pipes. Two of these are concealed in the front stud wall, another is hidden in a stairway riser, and the fourth is in an inside wall.

One Fixable Leak

A Bituthene membrane was used to waterproof the outside of the concrete walls and roof. On the roof, the Bituthene was applied directly to the concrete and a single 4-inch thickness of high density extruded polystyrene was laid over it. Four inches of sand was placed over the polystyrene, and then 10 inches of soil. The sand layer was intended to intercept any water that gets through the dirt and drain it off to the front of the roof where it would be collected by a perforated drain pipe. It is

Recesses in the concrete walls are good for displaying art works.

not clear whether the sand layer was needed. The only problem with the roof was a leak around one of the pipes going through it. The leak was found to be caused by a pucker in the Bituthene, and was readily corrected.

Thinking Ahead

Conduit containing electrical wiring was placed in a 4-inch PVC pipe, so it could easily be withdrawn in case repairs were needed. One construction technique that saved a lot of effort was the use of drywall mud to fill cracks between the sheets of plywood in the roof forms before the concrete was poured. This resulted in a smooth ceiling surface that required only a minimum of additional smoothing before the drywall finish could be applied

Reasonable Cost, High Satisfaction

Exclusive of well and septic systems, the house cost approximately $76,000 to build, or about $36.20 per square foot. The Brewers kept costs at a minimum by doing almost all the work themselves. Costs were driven up by the high price of concrete in the Broadus area; $76 per cubic yard for the 225 yards required.

The Brewers are a young family with two of their four children still in diapers. Verna Jo is home most of the time with at least one of the children, and temperatures are kept high enough to be comfortable for the babies. The Brewers say the underground design of their house makes it easy and economical to maintain the desired conditions. After three years in their house, the Brewers are happy with its performance, and the family tradition of saving energy is continuing ◻

Design Saves Energy, Protects Environment

Bob and Nancy Ballou's house sits atop a low grassy knoll between the tiny town of Charlo and the majestic Mission Mountains. Numerous small ponds gouged out by ancient glaciers dot the open countryside, offering choice habitat for cattails and water birds. But the system is fragile, with thin topsoil covering impervious clay. "We put in a septic system to handle graywater (discharge from sinks, shower and bath, washing machine, and dishwasher), but we didn't want to empty toilets into the septic tank and risk sewage spilling over into the surrounding area," said Bob, a retired wildlife biologist who worked for the U.S. Fish and Wildlife Service. To avoid overloading the fragile environment, the Ballous incorporated a Clivus Multrum composting toilet system when they were designing their superinsulated house.

"When you design around a Clivus, you have to build the bathrooms and kitchen back to back so the garbage disposal dumps into the same tank as the toilets," he explained.

Composting System Works

The 4-foot x 8-foot x 5-foot tank for the Clivus composting toilet occupies a room in the basement. "The Clivus takes some maintenance, but it becomes routine," Bob said. "About four times a year I pump out the liquid, and remove a bushel or so of solids once a year. They make excellent 'manure tea' and compost for the flowers."

Bob controls a minor insect problem by spraying with Pyrethrin, an organic pesticide. "We're careful about what we put down the garbage disposal. Banana peels seem to attract fruit flies. But the Clivus has absolutely no odor," he added. A fan continuously ventilates the toilet.

Nancy and Bob Ballou placed their house to capture the magnificent view of the Mission Mountains to the east. The windows gain some heat from the sun, but it's the house's superinsulation that keeps the heating bills down.

Superinsulation Traps Heat

"My former boss built a well insulated house and urged me to consider that type of construction," Bob said. "It made sense. It's so often overcast here in the winter, it seemed that superinsulation would work better than trying to design for solar gain. We did look into earth-sheltered housing and bermed the lower portion of the house.

"We learned a lot about insulation from Brian Curran who was a builder in Butte at that time. He helped us with the concept, but the house was a little more custom than what he was building. Rob Sand, a builder in Charlo who was familiar with superinsulation, took over. He built the house as if it were his own."

Double 2 x 4 walls hold three layers of fiberglass batts. Overhead, a thick blanket of blown-in cellulose insulates the west ceiling and fiberglass batts insulate the ceiling above the loft and living area.

A continuous air-vapor barrier of TuTuff was installed in the walls and ceiling. "The air-vapor barrier is critical," Bob emphasized. "Don't put any more holes in it than you have to. When we

Owners
Bob and Nancy Ballou

Location
Charlo

Designer
Owner and Builder

Builder
Rob Sand and Doug Hicks
Sun Garden Resources
Route 1 Box 121-B
Charlo, MT 59824
644-2468

Style
1 1/2 Story with Walk-out Basement

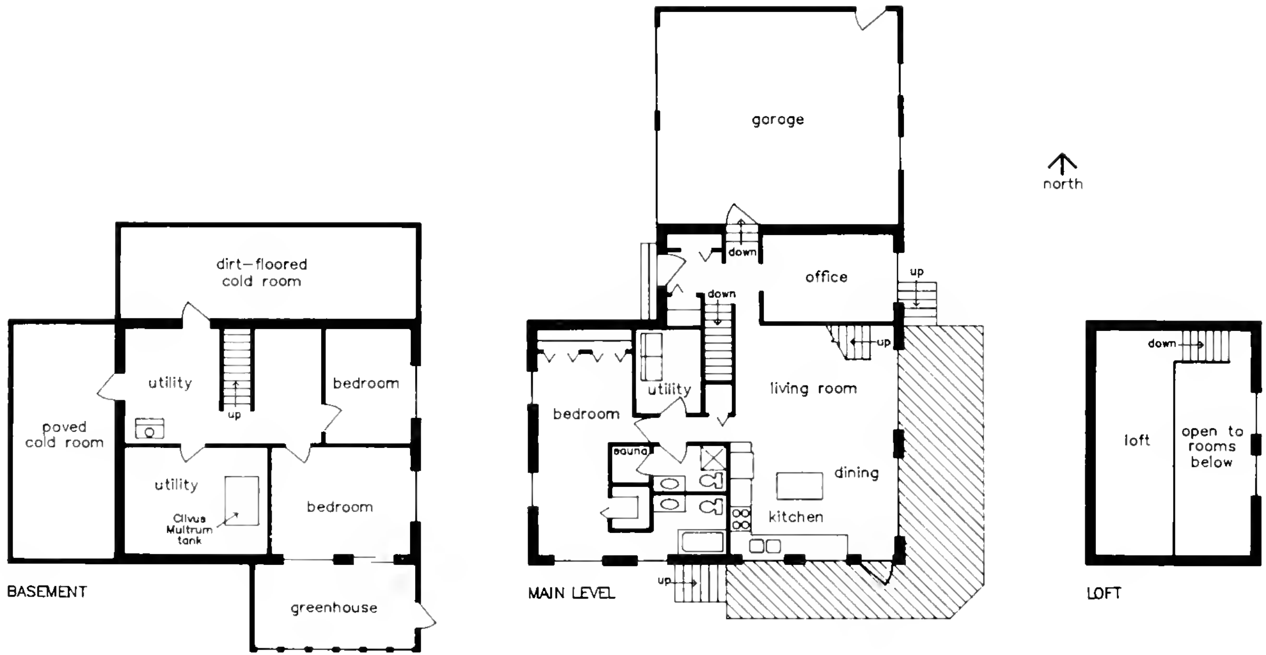
Insulation
Ceiling - R60
Double Wall - R40
Basement Wall - R19
Slab - R5

Square Feet
Loft - 280
Main - 1,540
Basement - 952

Special Features
Composting Toilet
"Cold Room"
Sauna
Outside Combustion Air

Heat
Wood Electric Baseboard

Completed
November 1983



put in a wood stove and had to puncture the polyethylene, we were very careful to seal it tightly with a heat resistant sealant that wouldn't deteriorate the polyethylene."

Although the windows are triple-glazed, some heat is lost through them according to Bob. "We haven't installed insulated window coverings. I figure it might take an extra stick of wood a day, and maybe not that much, to replace the heat going out through the windows. In summer, we leave the doors and windows open at night to bring in the cool air. About 9:00 a.m., we close the house up tight, pull the blinds to keep out the sun, and it stays cool."

A Memphremagog heat recovery ventilator provides ventilation. The ventilator is controlled by a time clock that turns it on for a fixed period each hour.

Register Fan Distributes Heat

During the first two years they were in the house, the Ballous relied on 18 feet of electric baseboard heaters to keep them warm. In 1985 they added a wood stove. Last season they burned about 2 1/2 cords of wood, and didn't use the baseboards at all. "The house retains heat," Bob said. "I haven't had the stove on since yesterday. This morning it was 6 degrees outside but at 9:30 a.m. it was 65 degrees in the living room."

The house's main heat source, the Osborn wood stove, is in the basement at the foot of the stairs. Because it is supplied by outside combustion air, the stove doesn't draw warm air from inside the house to feed the fire.

Air warmed by the stove reaches the main floor either by rising up the stairwell or by passing through a floor register at the far corner of the house. A fan in the register draws warm air across the basement ceiling and through the register.

Bringing the Outdoors In

The heart of the house is an open living room, dining area, and kitchen area. Two tall trapezoidal windows crown the lower windows on the east wall of the room, filling the house with light. From the dining area, a door to the spacious deck encourages outdoor lounging and meals.

Apart from the living space but connected to it by a large window, a special room contains shelves of colorful yarn and a knitting machine. "Nancy wanted space for her knitting activities without being isolated from the main area," Bob explained. "The window served that purpose."

A roomy master suite occupies the west side of the house. The Ballous particularly enjoy the cedar-lined sauna located just off the master bath.

Creamy walls complement the warm tones of the loft's balusters of western red cedar and posts and beams of spruce and pine. The kitchen floor of native sandstone accents the oak cabinets.

"The steam from the sauna dissipates in about half an hour. We have absolutely no trouble with condensation anywhere in the house," Bob said.

Earth Moderates Temperature of Cold Room

An underground "cold room" off the basement to the north is used to store fruits and vegetables. The room is on the same level as the basement and is reached through a door in the basement wall. The room has uninsulated concrete walls and a dirt floor, and stays at a nearly constant 45 degrees with 70 percent humidity. The floor of a similar room under the bedroom to the west was covered with concrete paving blocks over a 6-mil moisture barrier. This reduces the humidity to around 50 percent. The Ballous use the room for extra storage.

Basement walls are insulated with fiberglass batts. The basement slab is insulated with extruded polystyrene, and has a moisture barrier of 6-mil polyethylene.

On the south side of the house, patio doors lead from the basement to a spacious greenhouse under construction. When it's finished, the Ballous will have completed another step towards their goal of self-sufficient living in the Mission valley of northwest Montana. □

A Remedy for High Heat Bills

Owners
John and Barb Skoyen

Location
Chinook

Designer
Owners and Buffalo Homes

Builder
Buffalo Homes
P.O. Box 4080
185 South Parkmont
Industrial Park
Butte, MT 59702
494-5552

Style
Two-piece Modular with Basement

Insulation
Ceiling - R60
Stud Walls - R42
Basement Wall - R30
Slab - R10

Square Feet
1,280

Special Features
Superinsulation

Heat
Passive Solar, Wood,
Electric Baseboard

Completed
September 1985

For John and Barb Skoyen, the remedy for winter drafts and high heat bills was a superinsulated pre-built modular home. Watching television in their old house, the Skoyens saw advertisements for Buffalo pre-built homes, suggesting the possibility of yearly heat bills less than $200. At that time, the Skoyens' heat bills sometimes ran more than $200 per month. "Those $200 bills were just killing us," Barb Skoyen said

Following up on the interest generated by the television ad, the Skoyens investigated Buffalo Homes, and eventually decided to purchase a 1,280 square foot modular house built by that firm. They designed the floor plan themselves, which is one of the options available from Buffalo. Delivered to their rural location north of Chinook, the house cost $52,000. Excavation and concrete for the full basement was another $6,000. The house with unfinished basement thus cost $45 per square foot of living space, but this could be almost halved by finishing the basement, which would double the living space for a small additional outlay.

South-facing windows warm both main floor and basement of the Skoyen house.

Cost More, But Worth It

The Skoyens said it cost about $8,000 more to build the house to superinsulation standards than it would cost to build an otherwise similar house to current HUD standards. They think it was worth it. "Our highest monthly heat bill for the last year was $20," Barb Skoyen said. The superinsulation features used by Buffalo Homes are shown in the Glossary. They include the double wall with three thicknesses of fiberglass batt insulation, polyethylene air-vapor barrier, double- and triple-pane windows, a heat-recovery ventilator, and a thick layer of ceiling insulation.

Participation Required

One thing the Skoyens have learned about living in a superinsulated house is that achieving maximum comfort and energy efficiency requires participation by the occupants. Operating the heat recovery ventilator at the right level, for example, requires experience and practice. "It takes a while," Barb said. "You've got to get used to it." Some aspects of making the house comfortable require only common sense. For example, when days are hot and nights are cool, the Skoyens open the windows at night and close them in the morning. "It's just like it's air conditioned" John said. Once the house is cool inside, it

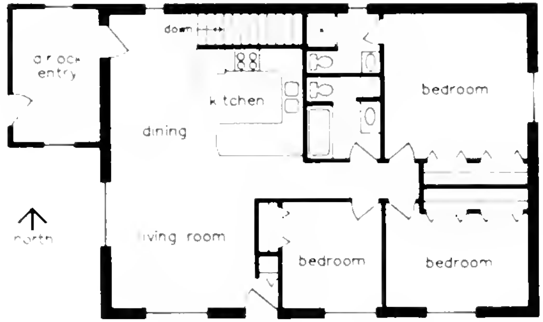
stays that way, he said. A roll-up awning on a west-facing window helps cut down on solar heating in the warm months when it is not needed.

Waste Heat Gets Used

The tightness of the house is such that small amounts of waste heat contribute significantly to space heating. The heat generated by the freezer, television and other appliances, light bulbs, and human bodies all makes a difference. The electric cookstove makes a particularly noticeable contribution, and Barb said that when they operate the cleaning mode of the self-cleaning oven, it produces enough heat to warm part of the house on cold evenings. The Skoyens have a wood stove in the basement, but they rely primarily on the solar heating they get through their south-facing windows, with a little help from their electric baseboards. John said the baseboard is used for backup heat when no one is home, or if they run out of wood. They normally use about five pickup loads of wood each winter. "Those are not tightly stacked loads," Barb said. If temperatures stay above zero, the Skoyens usually don't use the wood stove until evening, especially on sunny days. A pipe brings combustion air from outside so the wood stove does not drive heated room air up the chimney.

The Envy of the Neighborhood

The phenomenon of a superinsulated house is still rare enough in the Chinook vicinity to excite interest. John said that when cold weather comes he gets a lot of questioners wanting to know, "How's your heat bill?" The answer, the Skoyens are happy to say, is "Pretty small." □



Curtains control the amount of winter sun allowed to enter the Skoyen living room

Getting Out of the Wind

Owners
Dave and Ardene Zion

Location
Choteau

Designer
Owners

Builder
Owners
Zion Construction Company
Choteau, MT 59422
466-2005

Style
3 Story

Insulation
Roof - R52
Stud Walls - R25
Foundation - R10

Square Feet
Upper - 100
Second - 1,400
Main - 2,000

Special Features
Greenhouse
"Cool tube"
Use of Reclaimed Materials
Combination Urethane-Fiberglass Insulation
Wind-shedding Design
Crawl-space Plenum
Convective Heat Distribution

Heat
Passive Solar, Wood, Natural Gas

Completed
June 1987

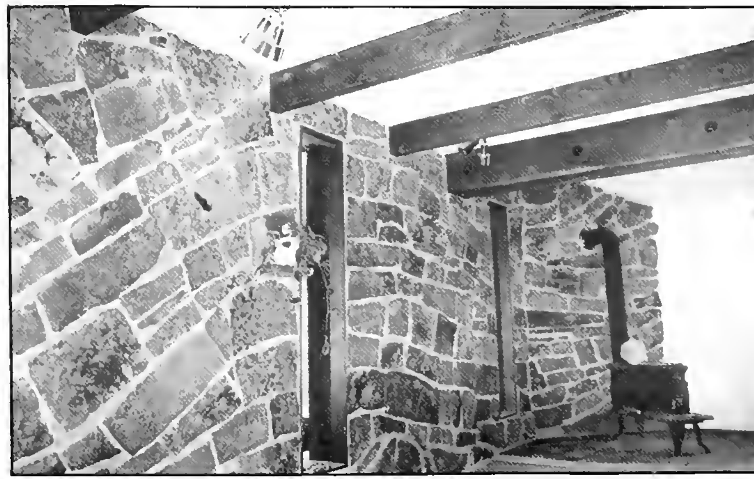
Building styles may change with time, but when building a house in the breezy open spaces of Montana, the first priority is always to escape the wind. When Dave and Ardene Zion of Choteau were planning the design of their new house, they knew its comfort and energy efficiency would depend in large part upon how well it could shed the winter blasts from the north.

The Zions employed a variety of strategies for dealing with the wind. First, they designed the house with a wedge shape and faced it to deflect cold north winds up and over the long side of the roof. The house has only two windows on the north side, one on the main floor and another in the third floor cupola where it is needed for ventilation. The garage is built into the house on the north side, which helps protect first floor living space from the north wind. On the second floor, a closet along the north wall runs the full length of the house. Further wind protection was provided by placing entrances out of the prevailing wind and installing airlocks on them.

A Place in the Sun

The south side of the house is designed to take advantage of the sun. The main solar feature is an 8 x 32 built-in greenhouse. Direct light entering this space warms the concrete wall at the rear, and this heat is radiated into the living space. The south side of this 8-inch concrete wall is corrugated and

A long roof to the north deflects winds over the Zion house. South-facing windows and greenhouse bring in the sun.



Decorative stonework adds mass to the inner side of the concrete wall between the greenhouse and the living room.

painted black to increase the capacity for solar heat absorption. The north side of this wall faces into the living room. The living room side of the wall is faced with 4 inches of ornamental stone, which increases the thermal mass.

The concrete and stone wall isolates the solar space from the living space, although three narrow vertical windows in the wall provide visual access between the sunspace and the living room. Skylights in the solar space and in the dining room-kitchen area provide natural light to the interior. Three skylights on the north side of the roof bring light to the second story.

Cooling it With a Tube

The 4-foot-deep crawl space under the house has an important role in the heating and cooling strategy. For cooling, a 14-inch culvert was installed to bring air from outside into the crawl space. This "cool tube" passes under the garage floor slab from the north side of the house. When cooling is needed, a window is opened in the third floor cupola. Warm air in the house is exhausted out the window by natural draft and replaced by cool air drawn into the house through the cool tube.

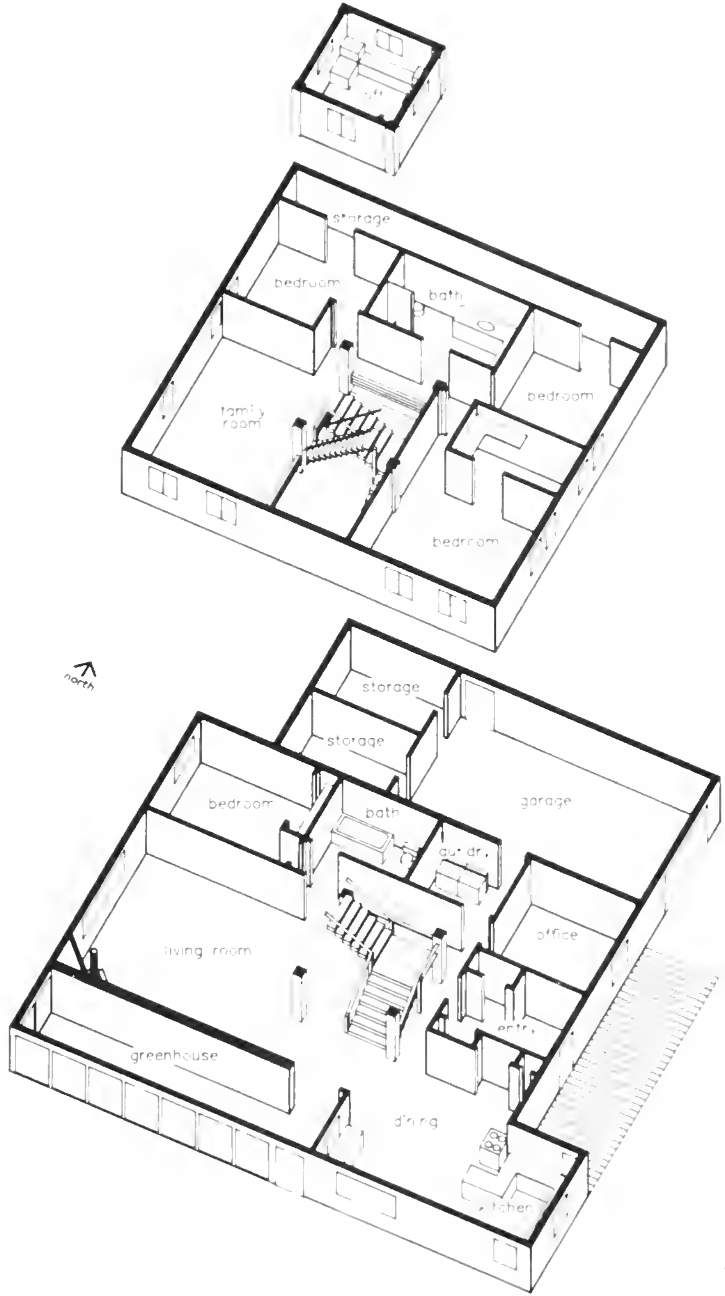
Crawl Space Acts as Heat Plenum

For heating, a Heil 96-percent-efficient natural gas furnace on the ground floor blows warm air down into the crawl space. The heated air rises by convection through floor vents to the living space. This heated air warms each level as it gradually rises to the third floor where it is drawn through a return vent. The air is then ducted back to the furnace where it is reheated and blown again into the plenum to continue the cycle. When the heating season begins in the Fall, Dave gets into the crawl space and covers the end of the cool tube with a piece of plywood to keep heat from escaping.

The furnace supplements the substantial amount of solar heat collected through the greenhouse and south-facing windows. Supplementary heat also is available from two wood-burners, one a heating stove and the other a cook stove, both on the main floor. Both wood stoves and the gas furnace receive combustion air through a pipe from outside.

Non-conventional Walls

Exterior walls are single-thickness, built with 2 x 6 studs, 16 inches on center. Two types of insulation were used in the walls. Two inches of urethane was foamed into the outer portion of the wall, with 3 1/2-inch fiberglass batts applied inward from that. The foam also functions as an air-vapor barrier. (DNRC building specialists noted that the dew point [see Glossary] in this wall would always be located inside the urethane under any combination of contributing conditions. The urethane is thick enough to act as an air-vapor barrier, preventing water vapor from penetrating to the dew point and condensing.) A 2-inch foam layer also was used in the roof, along with 12-inch fiberglass batts. Total R-value of the wall insulation is R25. Roof R-value is about R52. Two-inch extruded polystyrene sheets were used to insulate the outside of the concrete foundation. With the insulation on the outside, the 8 inches of concrete can function as thermal mass in the crawl space, heating up when warm air is present, and returning this heat later when the crawl space air is cooler than the concrete.



No insulation was placed in the bottom of the crawl space, although a 6-mil moisture barrier was installed, with 6 inches of sand over that. (DNRC building specialists suggested that the efficiency of the system could have been improved somewhat if the bottom of the crawl space had been insulated, and if more insulation had been applied to the concrete walls. Dave said the large number of floor vents he installed results in heat being rapidly distributed to the living space, which he expects to minimize heat losses. He limited the insulation of the crawl space to keep costs down.)

Double Pane Windows

All windows are Pella double-pane. Windows on the west side of the ground floor are equipped with SlimShades, which are small Venetian blinds between the panes. These blinds can be used to shut out the late afternoon sun and prevent overheating. The Zions plan to design and build insulated covers for the greenhouse windows. Doors to the outside are insulated wood, manufactured by Nord.

A Rugged Individual

The inside of the house has a rugged, well-crafted character, resulting mainly from the skillful use of recycled materials. Massive timbers reclaimed from an old bridge impart a hell-for-stout motif, particularly in the stairway structure. All rafters and floor joists were salvaged from an old Ford garage.The recycled bricks used in the chimney were originally manufactured nearby and reclaimed from an abandoned bar and machinery store. Beveled decorative glass from an old storefront provides a touch of delicate elegance in its new location above the main entrance of the Zion house.

Dave Zion, owner of the Zion Construction Company in Choteau, said he built the house himself in his spare time over five years. He said the materials used would cost $100,000 if bought new at today's prices, but cost him much less because so many of them were recycled.

Dave and Ardene said they are very pleased with their house, which is warm and comfortable. Dave said the highest heat bill during their first eight months in the house was about $45, for January, 1988. □

Corrugated concrete wall (at right) collects solar warmth in the Zion greenhouse.

Solar House in a Wood Stove Neighborhood

From their cozy house at 5,400 feet elevation high up on the side of Clark Gulch outside Helena, Terry Brown and Gwen Knight keep an eye on their neighbors to see if winter is coming. "We noticed the other day that some of them had their wood stoves going," Terry said on a brisk day in late October.

Long after the chills of autumn have set the wood stoves going for most people in conventional houses, Terry and Gwen stay warm with the sun that floods through the large south-facing windows of their modern, energy-efficient house. It is not good luck that brings bountiful sunlight into the house. The long axis was carefully positioned for maximum exposure to the winter sun, and the superinsulated walls and ceiling retain whatever heat is gained. On cloudy winter days, or at night when it's cold enough outside to freeze the ears off a brass monkey, the 14 feet of electric baseboard heaters turn on to chase the chill away. In the summer when the sun can be too much of a good thing, a 3-foot overhang on the south side keeps direct sunlight from coming in the south windows.

The Brown-Knight house was sited to face precisely in the right direction to get the most sun during the cold months of the year. The shadow on the end of the house shows sun angle at about noon, October 27, when photo was taken

The Case of the Disappearing Heat Bill

The effects of the energy-efficient solar design are readily apparent. For example, records show that Terry and Gwen's total heating bill for the year from June 1, 1985, to June 1, 1986, was $60.24. Their monthly electric bill for uses other than heat during this period averaged $30.30, totaling $363.60 for the year. Terry and Gwen have precise records of their electricity use because the house was built in compliance with the Bonneville Power Administration's Residential Standards Demonstration Program, which requires that electricity used for space heating be metered separately from that used for other purposes.

State-of-the-art Heat-saving Equipment

Energy-efficient features besides insulation include a continuous polyethylene air-vapor barrier, a heat recovery ventilator, double-pane low-E glass in operable windows and triple pane in the others, and an air-lock entry. The north side has no windows. Penetrations of the ceiling air-vapor barrier were kept to a minimum, with only three overhead lighting fixtures.

Intelligent Life Also Helpful

Technology is the heart of energy conservation programs, but the success of such efforts also depends on a certain amount of caretaking by the people living in the houses. "You've got to be

Owners
Terry Brown and Gwen Knight

Location
Clancy

Designer
Owners

Builder
Buffalo Homes
P O Box 4080
Butte, MT 59702
494-5552

Style
1 Story with Basement

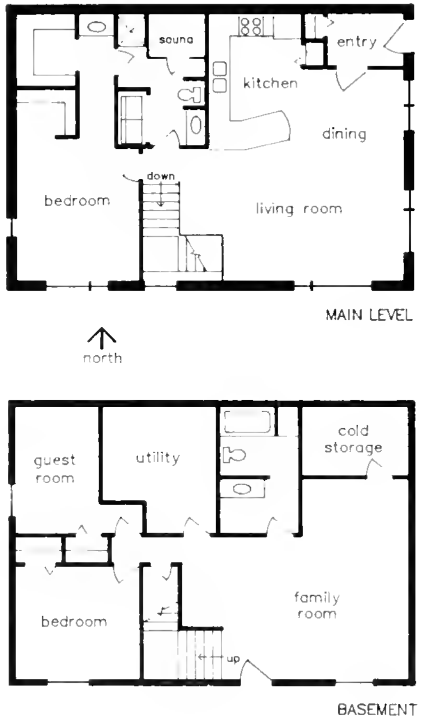
Insulation
Ceiling - R60
Walls - R41
Basement Wall - R30
Slab - R10

Square Feet
Main - 1 176
Basement - 1 134

Special Features
RSDP Construction
Superinsulation
Owner-designed Pre-built Modular Construction

Heat
Electric Baseboard

Completed
July 1984



diligent when it comes to saving energy in these houses," Terry said. One aspect of home energy efficiency that requires care is operation of the heat recovery ventilator. Terry said that he and Gwen set their ventilator on "low" under normal conditions and manually turn it to high speed when necessary to eliminate excess humidity created by showering or cooking. The ventilator froze twice, but this problem seems to have been eliminated by the installation of a defrost mechanism designed to prevent such freezing. "The Buffalo Homes people have been super about coming back under warranty to solve any problems we have had," Gwen said.

The Capture of Fugitive Heat

A little heat goes a long way in a superinsulated house, Terry said, noting that the warmth generated by cooking or showering often is enough to raise the indoor temperature by several degrees. This ability to retain heat helps keep Gwen and Terry's electric baseboard heaters unemployed most of the time. "When we get home from work after a sunny day, it's normally 62 to 65 degrees in the house, even if it's 20 below outside," Gwen said, adding that they usually leave the electric heaters off during the day.

Unmitigated Enthusiasm for Saving Energy

After living in their new house for more than three years, Gwen and Terry are sold on energy efficiency as a way of life. "We sure don't miss the wood stove from our old house," Terry said. Gwen and Terry agree that they wouldn't change the design a bit if they were to buy another house, though they might go about some of the preparations a bit differently. For example, they said, they would try to be more diligent about getting subcontractors to do what they wanted them to do. As it was, they said, they had a hard time getting subcontractors to build the foundation and basement the way they wanted it. "I seriously considered a wood foundation," Terry said, "but decided against it because I couldn't find anybody who knew how to build one."

All those decisions are past, and now Gwen and Terry bask in the warmth of the winter sun through the long months when their neighbors are wrestling half-frozen logs into their wood stoves. □

Superinsulated modular houses like the Brown-Knight Buffalo Home are the same inside as any modern house. The oak batten strip up the wall and along the ceiling covers the seam where the two halves of the structure join.

The Need for a Warmer Place

Starting as a young ranch wife living in drafty old ranch houses, raising a family and wondering what was going to happen to the price of calves, and later becoming a school teacher on the side, Jerry Arthun used some of her spare time to reflect on how a house might be built to keep frost off the inhabitants.

Interviewed north of Clyde Park in the Arthuns' bright modern ranch house that incorporates many of her ideas, Jerry said, "For 30 or 40 years I told myself that if I ever built a house, I was going to use the sun to help keep it warm."

By 1983 when the Arthuns were ready to build a new house, a lot of people had come around to the idea that it was good to bring the sun into the house for warmth. Another of Jerry's ideas whose time had come was the use of earth-sheltering to protect houses from the weather.

Long before the Arthuns started building their house, they selected a south-facing hill where they wanted to locate it, intending to sink it part way into the ground to escape the frigid winter breezes. This idea was encouraged by various publications regarding such strategies. The underground house book from Rodale Press was particularly useful, Jerry said. When the Arthuns took their ideas to an architect, he referred them to the same book, not realizing they practically had it memorized already.

The Arthuns' long anticipation met temporary disappointment when no water could be found on the hill they had selected for their house. Their good ideas were portable, however, and they moved their proposed building site to a bench overlooking the Shields River. The house they built there is an impressive structure with an earth berm on the north to deflect the winds and plenty of windows on the south side to bring in the sun. Windows in the clerestory and small windows above the berm on the north side bring daylight into every part of the house. All windows are double pane.

The house is built on a single level, with a double garage on the west side to provide some additional buffering between the outdoor weather and the living space. Jerry said they didn't want a basement because "a basement only accumulates stuff."

The Arthun house is warm in any weather.

The Sun First, Then Electric Heat Mats, Wood

Solar heat is supplemented with an electric heat mat under the gray tile floor at the front of the house, and with a Vermont Castings "Vigilant" wood-burning stove in the "ranch room" at the west end of the house. Jerry said Len likes to start a crackling fire to warm up after a chilly day of calving, feeding hay, or working cattle. A massive granite fireplace at the east end of the house provides the cozy feeling that comes with an open fire. Jerry said they use about 2 cords of wood each year.

Heat absorbed by the mass of finely-crafted stonework around the fireplace and near the wood-burning stove helps keep the house warm long after the fires have gone out. Several ceiling fans keep

Owners
Len and Jerry Arthun

Location
Clyde Park

Designer
Owners and Architect

Architect
Dick Prugh
Mattson, Prugh & Lenon, Architects
27 East Main Street
Bozeman MT 59715
587-1255

Builder
Easton-Hiller Construction
Livingston, MT

Style
1 Story Bermed

Insulation
Ceiling - R38
Stud Walls - R16
Concrete Walls - R17
Slab - R5

Square Feet
2,200

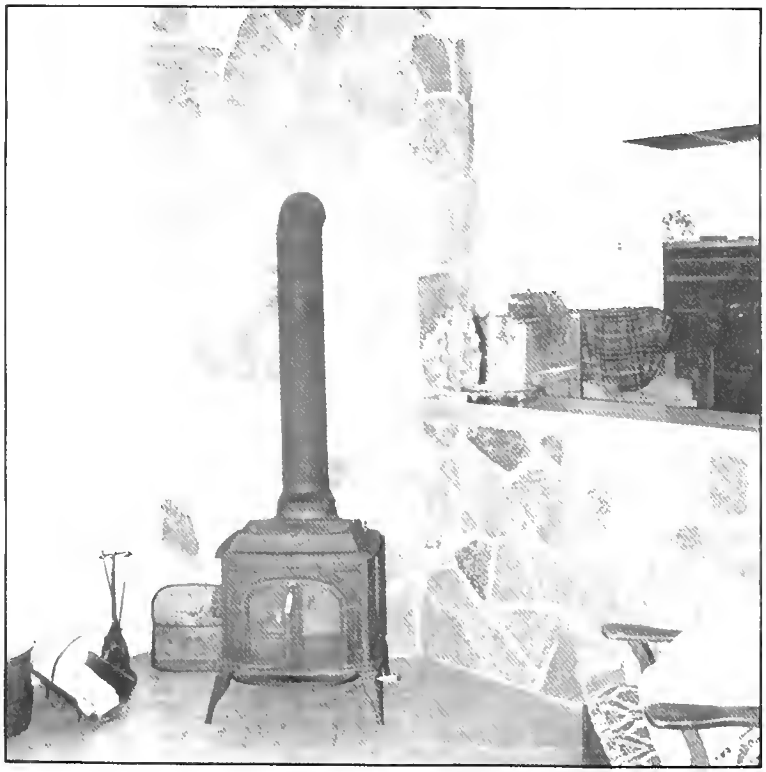
Special Features
Electric Heat Mats Embedded in Concrete Floor
Bermed
Thermal Storage

Heat
Solar, Wood, Electric Heat Mats, Baseboard Heaters

Completed
April 1983

Design for warmth south-facing windows on main level and in the clerestory, ceiling fans, and radiant electric heat mats in the tile floor in the foreground.

The wood stove in the "ranch room" helps take the frost off after a cold day's work.



warm air circulating in the winter, and help with cooling in the summer. The earth berm also helps with the cooling by keeping summer heat away from the north wall.

Insulation Keeps the Heat

Footings for the house were placed a full 6 feet below grade, with 2 inches of extruded polystyrene foam board insulation on the outside of the foundation. Concrete walls also were insulated with 2 inches of extruded polystyrene on the outside and 1 1/2 inches on the inside. The front stud wall is a standard 2 x 4 construction, 16 inches on center with R11 fiberglass insulation. Insulation value was boosted with 1 inch of extruded polystyrene installed under the siding on the outside of the wall. The floor slab is insulated with 1 inch of extruded polystyrene around the perimeter and under the heating mat. This heating mat is approximately 30 feet long by 5 feet wide, and is located in the floor along the south side of the house. Dick Prugh, the architect for the house, said heating mats have approximately the same efficiency as electric baseboard heaters.

Modest Heat Bills

Jerry said that the average monthly heating bill since they moved into the house in 1983 has been $46. Their highest bills were in January, 1984 ($130), and December, 1985 ($120). The Arthuns said these bills were for heat only, and they have their other electrical equipment on a separate meter so they can keep track of their heat costs. The heat bills probably could have been kept lower, Jerry said, "But we weren't trying to win any prizes. Besides, after working all day out in the cold, it's nice to come home to a WARM house."

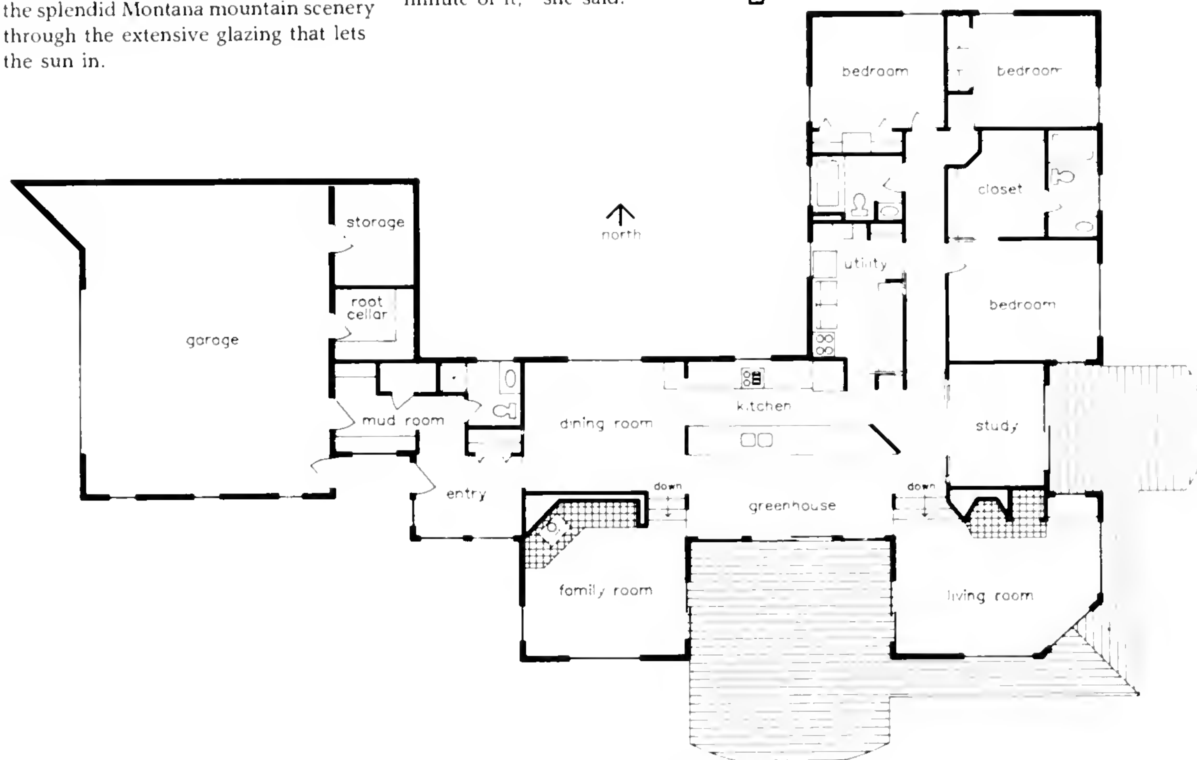
A Pleasant Blend With the Surroundings

Aesthetic considerations played a major role in the siting and design of the Arthun house. The first goal was to minimize the visual impact on the landscape. Another goal was to provide a view of the Crazy Mountains to the east and the Absaroka Range to the south. These goals were handsomely met, with the house blending pleasantly into the natural surroundings, and a fine view of the splendid Montana mountain scenery through the extensive glazing that lets the sun in.

The interior of the Arthun house is tastefully decorated with earth colors, and Jerry said that when they selected the colors they were mindful of what was likely to get tracked in by people who work around cattle all day. "Everything in this house matches the color of cow manure," she said.

All's Well that Ends Well

Given the evidence, it seems the Arthuns' 40-year daydreams of a new house warmed by the sun have been realized. Jerry said they wouldn't build their house any differently if they were to do it again. "We're loving every minute of it," she said. □



Escape From a Drafty Trailer

Owners
Don and Sandy Broesder

Location
West of Conrad

Designer
A Calvin Hoiland, Architect
2826 Third Avenue South
Great Falls, MT 59405
761-0594

Builder
Owners

Style
1 Story, Bermed

Insulation
Ceiling - R44/R34
Front Stud Wall - R19
Concrete Walls - R10
Foundation - R4

Square Feet
1,600

Special Features
Bermed
Integral Greenhouse

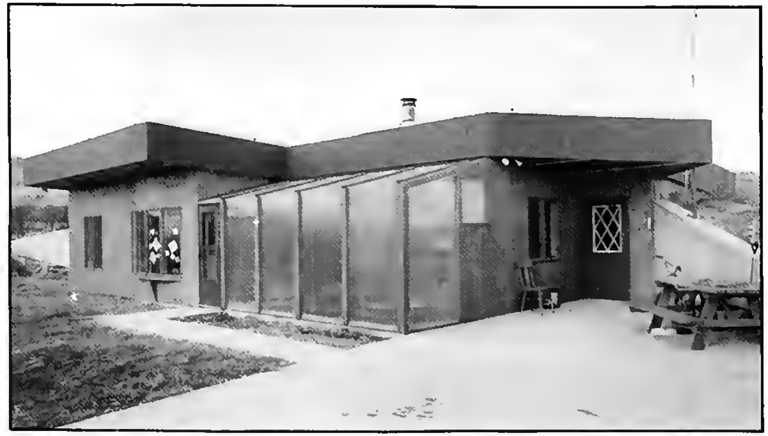
Heat
Solar, Wood, Electric Forced-air, Electric Baseboard

Completed
November 1984

Old-time Montana ranchers liked to hide their ranch buildings down in a coulee or drainage where they were out of the elements. Even at these relatively sheltered sites, however, the Montana weather can make life unpleasant for people whose dwellings are not right for the climate. Don and Sandy Broesder lived for years in a drafty trailer at the bottom of a draw on the family ranch 15 miles west of Conrad. When they finally were in a position to build a new house, they knew they wanted a place that was sheltered from the wind and easy to keep warm.

They considered various strategies to achieve these goals, and decided to use the earth to keep the wind off. They didn't want to go too far from home to build a house, so they built it a few feet west of their trailer. They hired an architect to do the design and they did most of the construction themselves, with a little help from hired labor and subcontractors.

The house, completed in November 1984, is built on a single level with 1,600 square feet of floor space. It faces a few degrees west of true south. Large, low-E double-pane windows admit sunlight on the south side of the house. An attached greenhouse 7 feet x 18 feet is built into the southeast corner of the house, at a level 2 feet below the rest of the house. This greenhouse is used mostly to provide heat for the living space, although the Broesders keep a few house plants in it and also use it for starting garden plants. The greenhouse contains several black-painted 55-gallon steel drums filled with water to store heat from the sun. Warm air from the greenhouse can be brought into the living space by opening the door or one of the two windows in the wall between them. Glazing in the greenhouse is Exolite, a double pane plastic material that Broesders say works well for greenhouse applications.



The greenhouse on the Broesder house has no shading and tends to overheat in summer

Underground Shelter from the Storm

The house is sunk part way into the ground to provide shelter from the storm, but the roof rises about 3 feet above ground level. As with most earth-sheltered structures, the rear wall and side walls of the Broesder house are 8-inch thick concrete. The front wall is a single-thickness 2 x 6 studwall, insulated with 6-inch, R19 fiberglass batts. The floor in the front portion of the house is a 4-inch concrete slab poured over 6 inches of compacted gravel. At the rear of the house, a conventional wood-frame floor covers a 3-foot deep crawl space.This space is 9 feet wide and runs the full 47-foot length of the house. The laundry room, bathrooms and kitchen are all over or near this crawl space to provide easy access and maintenance for water pipes and drainage lines.

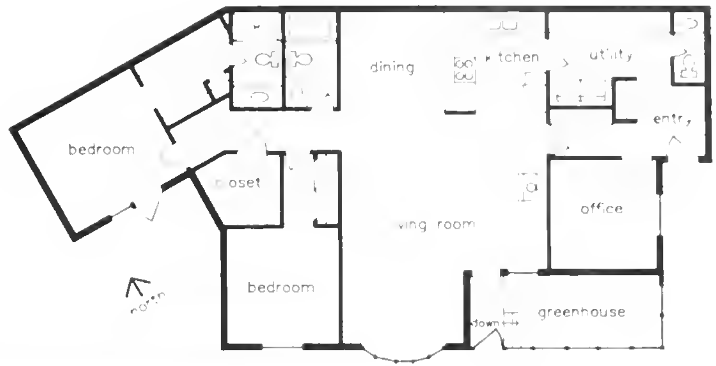
Various Insulation Strategies

Various thicknesses of expanded polystyrene foam were used to insulate the concrete walls. An inch and a half of the foam was applied to the inside surface of these walls. One inch of foam with a troweled-on protective coating was applied to the outside of the sub-grade walls down to a depth about 3 feet below grade. It also was used to insulate the outside of the foundation walls.

Half-inch drywall was placed over the foam to finish the inside walls. A 4-mil polyethylene air-vapor barrier was installed between the drywall and the insulating foam on the walls, and above the drywall in the ceilings.

Holding up the Roof

Roof structure for the longest spans (up to 33 feet) is supported by 20-inch TJI roof joists (see Glossary), 24-inches on center. Depending on their length, shorter spans are supported either by standard 2 x 10 joists on 16-inch centers or by 14-inch TJI joists on 24-inch centers. The portions of the roof with the 24-inch or 14-inch TJI joists are insulated with two layers of 6-inch fiberglass batts, to an insulating value of R38. A single 9-inch layer of fiberglass batts with an R28 value was installed in the portion of the roof with 2 x 10 joists.



Sunlight provides a major portion of the heat for the Broesder house.

The roof structure is built up with 5/8-inch plywood nailed on top of the joists and 1 inch of urethane foamed in place over the plywood. This foam adds about R6 to the insulating value of the roof. A Hypalon coating was applied over the foam. Five 20 x 20-inch triple-pane skylights bring light to the back portion of the house.

Keeping Things Warmed Up

Most of the heat for the house is provided by the sun flooding through the south windows into the greenhouse and living space. Supplementary heat is provided by two 1 500 watt fan-assisted

electric resistance heaters and two electric baseboard heaters. One of these 6-foot baseboard heaters is in the master bedroom and the other is in the bedroom shared by the Broesders' two young sons. Some additional heat is provided with a Buck wood-burning stove. Sandy said in the winter she starts a quick fire about every other morning and then lets it go out as the sun takes over to warm the house. About half the time she starts another in the evening. The supplementary heat needs of the house on a given day depend substantially on how much sun is available that day, Sandy said. Don said the Buck stove runs through about a cord of old fence posts each winter.

Heat Costs Not Known

All appliances including the water heater are electrical, and various electrical equipment for the ranch operations is run off the same meter, which makes it impossible to know what portion of the total electric bill goes to heat the house. The Broesders are satisfied with their home and they don't think it costs much to heat. They have no major regrets about the house, but if they were to build it again, they would enlarge the master bedroom and the laundry room. They also would like some shades or shutters for the greenhouse, which overheats in the summer.

Total cost of the house was about $72,000, which amounts to $45 per square foot. The Broesders said the use of an unconventional design did not affect their ability to get financing for the house. □

Don Broesder in his greenhouse. Oil drums are filled with water for heat storage.

A Bevy of Energy-saving Ideas

Dave Oien is one of those people who takes energy conservation seriously. Back in 1978 when he started building a new house on the family ranch near Conrad, energy conservation was one of his main considerations. The house that he and his family completed and moved into the next year embodies a wide variety of energy-saving strategies. These strategies include the use of vertical-wall solar collectors, a Russian furnace, 180 square feet of south-facing glazing, a substantial volume of indoor masonry to provide thermal mass, and an earth berm on the north side. Dave said he got many of his ideas from the Alternative Energy Research Organization (AERO), of which he claims to be a fanatical member. He had complete freedom to incorporate these energy-saving ideas, because he built the house himself with the help of family and friends. Total cost was about $49,000, or $22 per square foot.

"When we were building our house," Dave said, "one of the neighbors said it looked like a chicken coop. We took it as a compliment." Since then, at least two of the neighbors have threatened to build themselves a house just like Dave and Sharon's "chicken coop," Dave said.

The Oien-Eisenberg house is designed to take maximum advantage of solar power. Note the two-story flat-plate solar collectors on the outside south wall.

Sun and Insulation Save Firewood

The reason Dave and Sharon's house impressed the neighbors is clear: it normally takes only 1 1/2 to 2 cords of firewood along with the solar heating to keep the 2,016 square feet of floor space at a comfortable temperature over a winter. Much of this wood is fuel for the wood-burning cookstove, which is used to do the cooking from October through April and provides a measure of space heat in the bargain.

The exterior walls of Dave and Sharon's house are single 2 x 6 stud walls insulated with R19 fiberglass batts. Dave said if he were building today he would make the walls thicker and include more insulation. Ceiling insulation is a double layer of R19 batts, for a total value of R38. Extruded polystyrene foam under the floor slab has a value of R7, with foam on

Slots in the wall function as air intakes and outlets for the solar collectors

Owners
Dave Oien and Sharon Eisenberg

Location
Northwest of Conrad

Designer and Builder
Owner

Style
2 Story

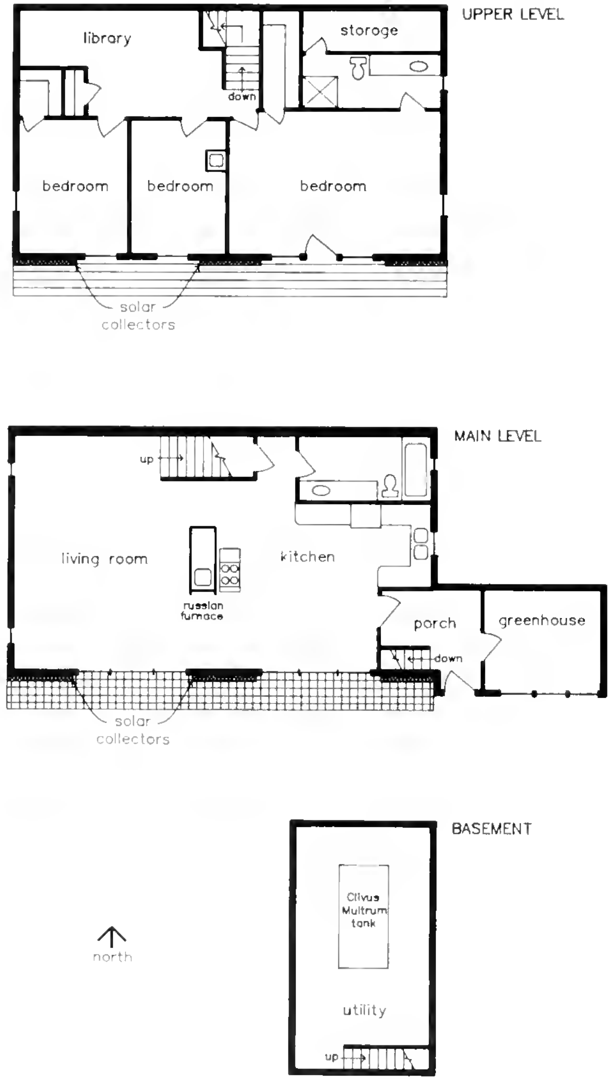
Insulation
Ceiling - R38
Walls - R19
Slab - R7
Foundation - R22

Square Feet
2,200

Special Features
Russian Furnace
Wind-powered Commercial Electric Water Heater
Home-made Vertical Wall Solar Collectors
Composting Toilet

Heat
Solar Wood

Completed
1979



the outside foundation walls to a value of R22. Windows are triple-pane glass. Dave and Sharon use "Warm Window" thermal curtains to insulate the windows on cold nights. Vertical, spring-loaded battens beside the windows are closed manually to clamp the curtains firmly to the framing around the window, providing a dead-air space between curtain and window. Dave said the windows are the primary source of solar energy in the house.

The homemade vertical wall solar collectors also work well and provide heat for the house, Dave said. Spring-loaded closures had to be installed on the collector vents to prevent back-drafting of cool air from upstairs to the ground floor.

When Sun is Not Enough, Wood

The main backup heat source is the massive Russian fireplace. Centrally located on the ground floor, this fireplace is designed to burn wood quickly at high temperatures. The hot combustion gases pass through a long, winding flue where much of the heat is absorbed by the surrounding mass of brick masonry. This heat gradually warms the bricks, and eventually radiates into the living space over an extended period of time, usually about 16 hours. Dave said in cold weather he fires the fireplace in the evening, and heat is released little-by-little into the living space, with heating reaching its maximum at about 3 a.m. He normally does not make a fire in the fireplace in the morning unless it is colder than 20 degrees outside with no hope of sun. Indoor temperatures rarely go below 58 degrees, even when no one is home and outside temperatures are -25. Temperatures once dropped to 48 degrees in the house when no one was home for a 2-week period in December.

Thermal Mass Needs Redistribution

Dave said the house has more thermal mass than it needs downstairs, but not enough upstairs. Ground-floor thermal mass includes the concrete floor slab, the 3-inch layer of bricks over the slab, and brick facing on interior walls. If he had it to do over, Dave said, he would pour a concrete floor for the second level, to provide additional mass upstairs.

Greenhouse Does Not Participate

The attached greenhouse was designed for vegetable production in the winter, but proved too shady for this purpose. It now is used to overwinter "mother" plants that are used for commercial cuttings. The greenhouse does not provide any heat for the house.

Combustion air for the fireplace and cookstove comes from the outside through an 80-foot-long, 6-inch diameter plastic "earth tube," which is buried below frost level. In the summer this tube brings cool air into the house to replace warm air that leaves the house as a result of the "solar air conditioning" provided by the vertical solar collectors. The sun warms the air in collectors, Dave explained, causing it to rise in the collectors until it exits through upper vents to the outside. This effect causes room air to be pulled into the collectors at the bottom, and the room air is replaced by cool air drawn in through the earth tube. Cross ventilation is provided with east and west windows that can be opened to catch prevailing breezes.

Windmill Tilts Energy Bills

Further energy saving is provided by the use of a windmill to generate electricity for water heating. The Jacobs 2,500 Watt, 110-volt DC wind generator is a 1930s veteran that Dave got in trade for a load of surplus bricks. The generator is connected to the lower coil of Dave and Sharon's water heater, with Montana Power Company utility service connected to the upper coil. If the wind doesn't blow, MPC heats the water. If it does blow, the wind heats the water, and dries the clothes when they are hung out on the line. Dave estimated that his total expenditure for the wind generator and its tower was about $1,000, supplemented with lots of donated labor and advice. All these strategies pay off: utility bills for Dave and Sharon's house ran between $5 and $25 monthly until recent rate increases drove their bills up by 30 to 50 percent, Dave said.

Saving Water Too

Responding to the scarcity of water on the family ranch, Dave installed a waterless composting type toilet made by Clivus Multrum. Two problems have attended the use of this toilet. The first problem is the buildup of moisture. Twice a year, Dave uses a sump pump and garden hose to pump "compost tea" out of the toilet. Dave said this tea is odorless compost which he uses to fertilize flowerbeds.

The second problem with the Clivus system is the occasional backdraft that comes down the vent in calm weather. This has been remedied by installing a fan in the vent.

Dave said the efforts needed to keep the Clivus in operation are worth it, because the alternatives aren't very workable either. Dave's mother lives nearby and uses a conventional septic system which presents a different set of problems mostly relating to the amount of water necessary to operate these systems, the expense of occasional pumping, and the nuisance of malfunctions. The waterless operation of the Clivus is particularly appreciated because water is scarce in the vicinity, and the Oiens must truck water and store it in cisterns.

A Measure of Energy Independence

Dave and Sharon are well aware of the advantages of having a measure of independence from public energy utilities. "Every year the power gets knocked out for a day or two, but we can get by without it," Dave said. □

Massive brick Russian Furnace at left provides heat when solar power is not enough

A Chilly Little House on the Prairie

Owners
Chuck and Val Skorupa

Location
East of Conrad

Designer
Owners and Fred Quivik
Renewable Technologies Inc.
P.O. Box 4113
Butte, MT 59702
782-2386

Builder
Southwall Builders
644 South Second Street West
Missoula, MT 59801
549-7678

Style
1 Story with Basement

Insulation
Ceiling - R60
Double Walls - R40
South Greenhouse Wall - R19
Basement Walls - R34, R27
Slab - R10

Square Feet
Main - 1,700
Basement - 1,700
Greenhouse - 450

Special Features
Greenhouse
Earth Tube
Retrofit Construction

Heat
Passive Solar, Electric Baseboard

Completed
June 1983

Chuck and Val Skorupa had an OK little house on their farm near Conrad, and maybe it was typical of such houses built from the mid 1950s to mid 1960s: it got them by, but was not exactly comfortable in all weathers. It was drafty in the winter and hot in the summer. It leaked heat like a sieve. Besides which, it was a bit small. Twenty-five or more years ago when the house was built, insulation was not a major consideration. The uninsulated exterior walls had an R value of about 7, and the attic was about R11.

Chuck and Val Skorupa's retrofitted house is proof against cold weather.

A Cure for the Problem

Chuck and Val are members of AERO, the Alternative Energy Resource Organization, and they knew that it wasn't necessary for people to alternately freeze and fry in the discomfort of their homes. Consequently, after considering the options, they decided in 1982 that they would hire a contractor to expand their old house and bring it up to modern energy-efficiency standards.

They knew that Southwall Builders of Missoula had a good reputation for energy-efficiency retrofits, so they hired them to do the work. It was not a small job. First, the old house had to be moved off its foundation, which was deteriorating and in need of replacement. The old foundation then was demolished, and a new one built to fit the dimensions of the new house. The exterior of the concrete basement walls was insulated with extruded polystyrene foam boards; 3 inches of foam from the top of the concrete to a depth of 4 feet, and 2 inches from there to the footings. The interior surface of the basement walls was furred out with 2 x 4s set out from the concrete to allow room for 6-inch R19 fiberglass batts.

From the Ground Up

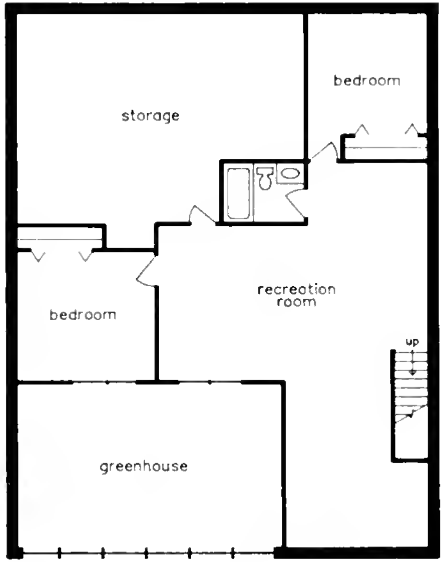
After the new foundation was complete, the original house was reset and reconstruction began. The square footage of the house was increased by adding approximately 15 feet to the east side. This expansion was enclosed by double 2 x 4 exterior walls, with R11 batts in the stud-wall cavities and R19 in the space between the two stud walls. Siding was removed from the original house, and a new 2 x 4 stud wall was built 6 inches outside the original stud walls. The double walls thus created were insulated in the same manner as the new double wall on the east side. The builders built a new roof with a roof peak 5 feet higher than the original roof peak, and placed R60 fiberglass batt insulation on the old roof.

A Thorough Modernization

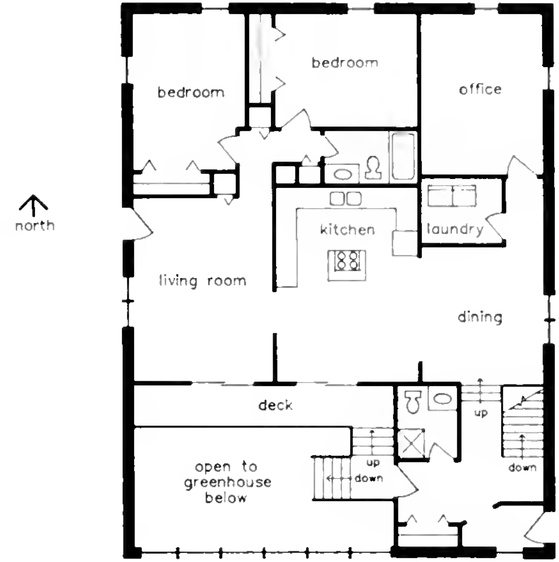
The new 18 x 26 greenhouse was added on a floor level midway between the basement and main floor. All old windows were replaced with Clawson double-pane with low-E film, and old doors were replaced with insulated steel thermal doors. A VanEE heat recovery

ventilator was installed to control indoor air quality in the tight new structure. Intake air for the ventilator passes through a 6-inch plastic pipe, most of which is buried below frost level so that cold air from outside is tempered before it reaches the ventilator. This reduces the amount of warming the ventilator has to do, and eliminates the freeze-up problem that sometimes is a problem with older heat recovery ventilators in cold weather.

The Skorupas moved into the house in June, 1983, and have been enjoying it ever since. The greenhouse has turned out to be a major contributor to home heating, and it is only occasionally that the Skorupas have to turn on a short length of electric baseboard heater for supplemental heat. With superinsulation, an appreciable amount of warming can be noticed even from the heat given off by people and appliances, Val said.



BASEMENT



MAIN LEVEL

The built-in greenhouse is a major heat contributor in the Skorupa house.

An Occasional Nip in the Greenhouse

Although the greenhouse is not equipped with a heater, it generally maintains a temperature level safe for plants, although some plants have been nipped at night when the outside temperature has dropped to 40 below or colder. During bright sunny winter days, greenhouse temperatures may range up to 100 degrees, even though outside temperatures are well below zero, Val said. She said that during the winter they close the greenhouse off from the living space at night, and open it during the day. This procedure is reversed during the summer. DNRC building specialists suggest that temperatures in the greenhouse could be controlled to some degree if shades or curtains were installed.

A Worthwhile Effort?

Converting an existing farm house to a modern energy-efficient home was costly and time consuming. The Skorupas said it cost about $79,000 for the conversion. Would they do it again if they were faced with the same situation?

The answer, Chuck Skorupa said, is no. "If I had it to do over, I'd put some insulation into the old house and use it for a bunkhouse. Then I'd build myself a new house." Steve Loken of Southwall Builders noted, however, that construction of a house with the features present in the Skorupa house probably would cost between $135,000 and $150,000. □

Montana's First Super Good Cents Home Returns Investment

Owners
John and Rita Johnson

Location
Corvallis

Designer
Owner and Builder

Builder
Campbell Massey
888 Coal Pit Road
Corvallis, MT 59828
961-3704

Style
1 Story

Insulation
Ceiling - R53
2 x 6 Strapped Wall - R32
Crawl Space Wall - R29
Crawl Space Floor - R10

Special Features
Super Good Cents Construction
Water Heater Timer

Square Feet
Main - 2,030

Heat
Electric Baseboard

Completed
November 1985

Rita and John R. Johnson's home north of Corvallis was the first in Montana to qualify for the Super Good Cents designation. Although the construction added $4,000 to the cost of the home to meet the energy-efficiency standards, it's already paying off in low heating bills and warm floors in the morning.

"When we go to bed, we turn the heat down to 60 degrees," Rita said "In the morning I get up and pad around in my bare feet. The house stays warm and the kitchen linoleum is never cold. If I open the draperies in the morning and the sun is shining, which it usually is, it heats up the house."

Heating Cost A Third of Average

The monetary return on investment began immediately. "From November of 1985 to November of 1986, the house cost $338 to heat, or less than $1.00 per day," Rita said. A home of similar design built to HUD standards would cost an average of $1,088 a year to heat. The difference based on today's electric rates means the Johnsons will save the $4,000 additional construction cost in a little over 5 years—or less, if the electric rates increase.

Heat Stays Put

But the payback is more than dollars. "One of the nicest things about this house is no cold or hot spots, and no forced air heat," John said. Electric base-board heaters radiate even, quiet heat,

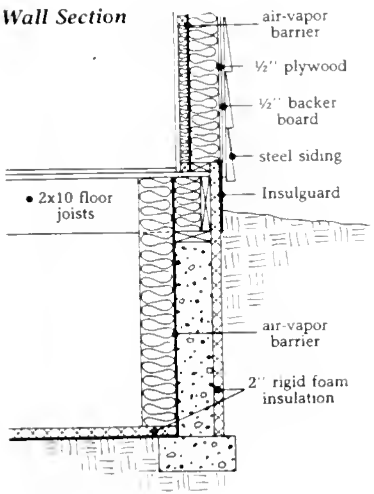
Practical features contribute to qualify John and Rita Johnson's home for the Super Good Cents award. North windows are restricted to one in each spare bedroom, one in the family room, and an entry sidelight. Placement of the insulated oversized garage and spare bedrooms on the north side reduces the need to heat these cooler areas.

All major rooms take advantage of passive solar heating by facing nearly due south, and, incidentally, capturing views of the Bitterroot and Sapphire ranges. In the summer, the 3-foot overhang keeps the high summer sunlight out of the living space and the sheltered patio on the southeast corner.

and tight construction makes sure it stays put. Cavities in the 2 x 6 walls are filled with blown-in cellulose. Raised-heel trusses in the ceiling allow room for 15 inches of cellulose. A continuous air-vapor barrier of 6-mil polyethylene sealed with Tremco keeps moisture out of the insulation and prevents warm air from traveling to the outside. To minimize holes in the air-vapor barrier for electrical outlets, 1 1/2-inches of furring was applied to leave a gap for wiring. Even this small cavity was filled with fiberglass insulation after the electricians were through. In the utility room, double walls frame the exterior wall. The 2 x 4 inside wall contains the service panel, wiring, and plumbing, which cuts down on the number of wires and pipes that penetrate the air-vapor barrier.

A dropped ceiling in the kitchen contains efficient fluorescent lighting. "We installed very few overhead lights to avoid disturbing the ceiling air-vapor barrier," John said.

Wall Section



Ventilation Keeps House Clean and Dry

A VanEE-2000 heat recovery ventilator brings in fresh air and exhausts stale air and moisture. It also minimizes dust. "This house is the cleanest we've ever lived in," Rita said. "The ventilator seems to filter the dust out of the incoming air."

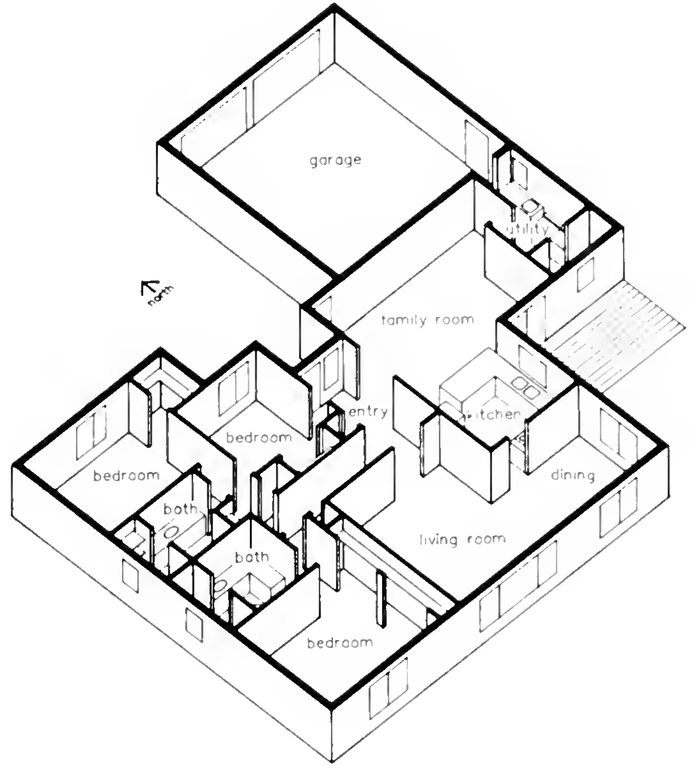
"We've never had any trouble with condensation," John added. "We built during the summer, which meant less moisture in the framing. It rained just once before we got the house covered.

"The type of soffit and ridge ventilation we have effectively moves moist air up and out of the attic," John said. He pointed to the 3-inch-diameter vents placed a foot apart along the soffit, and the continuous ridge vent. "I thought snow might get into the ridge vent, but we've had some heavy snowfalls and haven't had a problem."

After the Johnsons moved in, they ran the ventilator continuously for three months on slow speed to remove any moisture emanating from the paint, drywall mud, and other construction materials in the house. Now they run the ventilator at night and shut it off during the day. If the indoor humidity should exceed 50 percent during the day, a dehumidistat automatically turns on the ventilator. When it's below 20 degrees, they run the ventilator continuously to prevent condensation from forming on the windows.

John and Rita said they wish there was a way to prevent outside odors from entering the house through the ventilator. "We can smell wood smoke at times, and skunk odor is a periodic problem," Rita said.

The Johnsons have a couple of things they'd change. "We insisted on bathroom fans venting directly to the outside, in



addition to the ventilator exhausts," John said. "They aren't necessary, and we have them covered with foil now. Sometimes we can feel a draft in the family room from the fresh air vent in the hallway. I'd relocate that vent farther down the hall."

Equipment Housed in Insulated Crawl Space

The ventilator silently performs its duties in an unseen part of the house. A trap door in a hall closet opens to a stairway down to a "mechanical room"—actually an 8-foot x 16-foot area excavated somewhat deeper than the rest of the crawl space. "We put in the mechanical room so we could hang the ventilator from the floor joists and be able to get to it easily," John explained. He pointed out an insulated duct coming from the other end of the house. "That's the fresh air intake. The long run warms the air slightly before it enters the ventilator." The crawl space stays at an even 62 degrees, regardless of the weather. An air-vapor barrier covers the crawl space ground and walls. Twelve inches of fiberglass insulation was installed on the rim joists, with 6 inches on the inside walls.

Two inches of extruded polystyrene covers the crawl space ground and its exterior walls.

No Steps

A novel approach to the crawl space construction resulted in airtight, moisture-proof, well-insulated walls and more. Two-inch-thick extruded polystyrene foam board insulation was installed on the outside from the bottom of the studs to the foundation footing. To line up the foam board with the studs, the builder used a 2 x 4 bottom plate which let the 2 x 6 walls extend over the rim joist by 2 inches. Insulguard, a fiberglass shield, protects the above-ground portion of the foam board. The shield is held in place by the 1/2-inch exterior plywood sheathing and steel siding that laps over the foam board-Insulguard shell by 1 1/2 inches.

Embedding the crawl space in the ground almost to the siding minimized the amount of surface exposed. It also eliminated the need for steps to the front entry and lowered the profile of the house. Raised-heel trusses add several inches to the height of a house, but the profile of the Johnson's house is no higher than a conventional house.

Low winter sunlight creeping through south-facing windows will eventually reach the living room's back wall. In the dining room, large windows bring in east light All windows are Andersen double-glazed with low-E film.

Water Heater Timer and Anti-siphon Loop

In the mechanical room an energy-efficient 52-gallon State electric water heater sits in one corner, wrapped in a thick insulating blanket. Its central location allows short pipe runs to serve faucets and appliances in the living area above. To keep from heating water unnecessarily, a Paragon timer turns on the water heater for a set period each day. An anti-siphon loop on the top of the heater prevents hot water from being drawn back into the incoming cold water pipe. All hot water pipes and 5 feet of the incoming cold water pipe are wrapped with insulation.

Seminar Leads to a Good House

John and Rita are extremely pleased with their house. "We feel fortunate to have contacted Campbell Massey about building our house," Rita said. "He suggested we attend the Super Good Cents seminar at Ravalli County Electric Co-op.

"After the seminar, we put together a plan and Campbell and Rudy Kratofil (Conservation Supervisor at Ravalli County Electric Cooperative) incorporated the energy efficiency into it. If we were to start thinking about another house tomorrow, the builder would be Campbell Massey, and it would be an energy-efficient home." □

A House for Cut Bank Weather

Back in 1985, Lee McCauley decided to build a house in Cut Bank. The climate in Cut Bank being what it is, Lee knew he wanted a house that would keep the outdoors outdoors. A tight, energy-efficient house was what he needed Specifically, he decided he wanted a particular design known as an envelope house.

The Envelope House Design Idea

Envelope houses use a fairly elaborate design to take advantage of passive solar energy. This design uses circulating, solar-heated air to warm the house and buffer the living space from outdoor temperatures. The front (south side) of these houses has large windows on both upper and lower levels. Sunlight entering these windows heats the air in the sunspaces on both levels of the house. Air is free to rise from the lower level to the upper level sunspace through an opening in the floor between. Warmed air rises from the sunspaces to the top of the house. What the air does after it reaches the underside of the roof is uncertain. According to the envelope-house operating theory, the air should move northward through a passage provided for it along the underside of the insulated roof until it reaches the north wall. Then, the air is supposed to move down through the space left for it in the north wall until it enters the basement or crawl space. Once in the crawl space, the air theoretically moves to the south side of the house where it completes the cycle by rising through slots in the floor to replace air that has risen after being warmed by sunlight entering the sunspace.

Larry and Blondie Woolston's house in Cut Bank shows the style that characterizes envelope houses.

Some Envelopes Work, Some Don't

Testing by Brookhaven National Laboratories, a federal energy research facility, indicates that the circulation cycle does not work in some envelope houses. When Lee McCauley was considering building a house, he was acquainted with an envelope house near Ronan that did seem to work. He liked the modernistic looks of the envelope houses. "It was something different, and something we wanted to do," he said.

An Envelope House Comes to Cut Bank

And so an envelope house came to be built in Cut Bank. The house faces

Owners
Larry and Blondie Woolston

Previous Owner
Lee McCauley

Location
Cut Bank

Builder
Vogt Construction
P O Box 1346
Cut Bank MT 59427
873-2552

Style
2 Story Envelope Construction

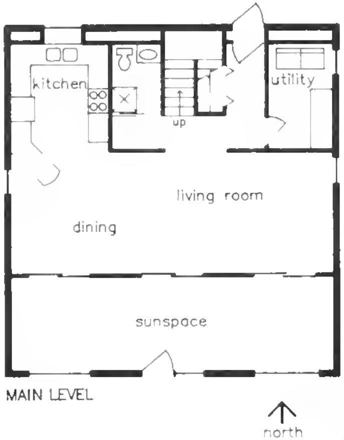
Insulation
Roof - R40
Stud Walls - R24
Lower Level Floor - R30
Crawl Space Floor - R5

Square Feet
2,176

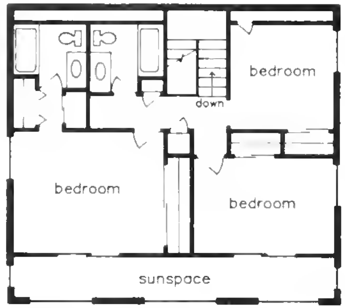
Special Features
RSDP Construction
Envelope Construction

Heat
Passive Solar Electric Baseboard
Fan-forced Air

Completed
1985



MAIN LEVEL



UPPER LEVEL

southeast to catch the first rays of winter sun, and its distinctive shape stands out among the conventional houses on the north side of town. The McCauley house has never been tested to determine whether the design is functioning as intended, but both Lee McCauley and the present owners and occupants of the house, Larry and Blondie Woolston, are convinced that it works.

There is no dispute that the McCauley house is highly energy-efficient. Records show that the house needed only 2,200 kilowatt-hours to heat it between May 3, 1985, and March 2, 1986. At this rate, it cost only about $110 to heat the house's 2,176 square feet of floor space for 10 months.

DNRC building specialists suggest that envelope houses are highly energy-efficient because the large expanse of south-facing windows allows the sun to provide a major contribution of warmth, and the thick, heavily insulated walls and ceiling keep the heat from escaping. In essence, they said, envelope houses

Windows at the ends of the upstairs sunspace can be opened to provide cross ventilation. Opening in the floor lets warmed air rise from the lower level sunspace.

The sunspace on the main floor is a good place for a hot tub. Doors at left can be opened for ventilation.

"operate just like big thermos bottles," adding that a house of comparable thermal qualities could be built for less than required by the envelope style construction.

Sparse Heating Equipment Worries Montana Native

The only heat backup for the sun in the McCauley house is three short lengths of electric baseboard heater, and a small fan-forced-air heater in each of the three bathrooms. Each of the two bedrooms has a short baseboard, with one in the kitchen on the main level. "The one on the main level is the only one we really use," Larry said. He said the sparse heating equipment in the house was "worrisome to a Montana native" such as himself until he realized the solar heating potential of the house.

The various electrical uses in the houses have separate meters, so it is possible to keep track of how much goes for what. In the mild winter month of February, 1988, for example, the Woolstons' heat bill was $12.68, Larry said, adding however that monthly bills can reach $30 during particularly cool spells of invigorating Cut Bank winter.

Strategies for Heating and Cooling

On the other hand, the sun can almost be too much of a good thing. "Sometimes on sunshiny days we have to open the windows, even in the winter," Larry said. He said the body heat from a few people can be enough to raise the temperature.

"It's really more of a cooling problem than a heating problem," Lee McCauley said. He said the summer sun shining in the windows tends to overheat the sunspaces, although this can be countered by opening the upstairs windows and letting the hot air escape. Side windows at the ends of the sunspace provide cross ventilation, and the Cut Bank breeze passing through from side to side provides plenty of fresh air, Lee said.

The house is equipped with a heat recovery ventilator, which the Woolstons operate manually when they shower or cook. Lee McCauley said he is convinced that the ventilator is not needed, and he would not put one in if he were building the house today. He contends that bathroom and kitchen vents would serve the ventilation needs of the house.

Shades Might Help

Lee said the overheating tendencies might be reduced by installing shades on the sunspace windows. At the time the house was built, he said, he couldn't find any shades he liked. The Window Quilt shades that were available took up too much space when they were rolled up, he said, noting that they required about 8 inches of space at the top of the windows.

Operating for Energy Efficiency

Lee and Larry agreed that the house must be consciously "operated" to achieve maximum energy efficiency. For example, Larry said, in cool weather, the Woolstons open the door between the living space and the sunspace in the morning as soon as the sun warms the air in the sunspace, and close it in the evening. Once warm, the living space stays warm because of the thick insulation surrounding it. In warm weather, they keep the living space closed off from the hot air outside, and they open the windows at the top of the sunspace to let out the hot air.

"The Nicest House We've Ever Lived In"

Larry said he and Blondie like the house very much, and wouldn't do much to change it except possibly make it a little bigger. "We sure do enjoy it," Larry said. "It's the nicest house we've ever lived in." □

Airtight Drywall Seals House

Owners
Tom and Susie Bramlette

Location
Dillon

Designer
Owner

Builder
Kim Baker
RBJ Construction
P.O. Box 427
Dillon, MT 59725
683-4337

Style
Split Level

Insulation
Ceiling - R60
2 x 6 Walls - R27
Crawl Space Floor - R11
Crawl Space Walls - R19
Basement Walls - R19
Basement Slab - R5

Square Feet
Upper - 898
Main - 1,189
Basement - 889

Special Features
RCDP Construction
Airtight Drywall Approach

Heat
Electric Baseboard

Completed
August 1986

In their house, Tom and Susie Bramlette used the advanced drywall approach (ADA) instead of installing a separate air-vapor barrier. Although some houses had been built with ADA in Canada and on the West Coast, DNRC records show the Bramlettes were one of the first to build a house in Montana using full ADA.

Builder Kim Baker of RBJ Construction in Dillon received a Residential Conservation Demonstration Program (RCDP) grant from DNRC and Bonneville Power Administration to cover the extra expense of building the Bramlettes' house to meet RCDP specifications, which included ADA as an innovative energy feature. Beginning in August 1986, DNRC began a year of electrical usage monitoring to see how ADA compares to other types of air-vapor barrier techniques. The results from monitoring of the Bramlette's house and other RCDP houses will be available in late spring of 1988.

Air-Vapor Barrier Must be Tight

The air-vapor barrier is an essential part of any energy-efficient house. It prevents drafts by stopping air from leaving or entering the house; it protects insulation and framing by keeping moisture out of wall cavities, attics, basements, and crawl spaces.

The airtight barrier most builders use is a continuous wrap of 6-mil polyethylene around the house frame. Proper installation requires careful attention to detail from nearly everyone on the work site,

The combination of the airtight drywall approach with heavy insulation and southwest-facing windows is chopping Susie and Tom Bramlette's electric heating costs to an average of $52.00 a month.

A step up, a bannister, and the meeting of vaulted ceiling with flat ceiling mark the transition from the one-level living room to the split-level portion of the house.

including carpenters, plumbers, electricians, and even the people who install the telephones and cable television lines. The seams of the polyethylene must be carefully overlapped and caulked, and any openings made in the film while installing windows, plumbing, and wiring must be sealed tightly.

Airtight drywall eliminates the separate labor-intensive step of installing a plastic air-vapor barrier and uses materials that are readily available. Unlike the polyethylene barrier hidden in the walls, the drywall air-vapor barrier is visible and easily accessible if repairs need to be made.

How It's Done

Airtight drywall is installed in three steps. First, closed-cell foam gasketing or caulk is installed between the drywall and the framing members (studs, plates, and so forth). This stops infiltration. Then the drywall is taped at all joints to seal it, and drywall mud is applied. The last step is painting the drywall with a low permeability paint to serve as the vapor barrier. Maintaining the integrity of the seal is easy. For example, should the house settle and a crack appear, it is a simple matter to caulk and repaint.

Like any new technique, ADA installation takes practice, but takes less time as builders become more experienced with it.

Insulation and Ventilation Part of the Package

The energy-efficient features of the Bramlette's house include more than tightly sealed drywall, however. Insulation and ventilation are basic components of the RCDP package. Six-inch fiberglass batts were installed in the 2 x 6 wall cavities and the studs were sheathed on the exterior with 1-inch polyisocyanurate foam board. Raised-heel trusses in the ceiling allowed room for a thick layer of blown-in fiberglass insulation. The concrete walls of the basement and crawl space were furred out with 2 x 6 studs and filled with fiberglass batts. R11 fiberglass batts were installed in the floor over the crawl space, and a 6-mil polyethylene moisture barrier was laid over crawl space ground. All windows are double glazed with low-E film. Cedar and brick provide a handsome finish to the exterior.

A VanEE-2000 heat recovery ventilator is controlled by a dehumidistat that is set to operate the ventilator when humidity rises above 42 percent. "We have absolutely no trouble with condensation," Susie said.

Congenial Comfort

The attention to detail carried over to the finishing touches on the house. The hardwood foyer features two slender north-facing windows and a green Persian rug. From the west side of the foyer, French doors open to an office. Here solid green carpeting continues the foyer's color scheme.

Plain white walls and oak paneling play up the living room's vaulted ceiling and brick fireplace on a raised hearth. A pipe brings fresh air from outside directly into the fireplace so the fireplace won't draw air from inside the house for combustion.

A step up and a small railing separate the kitchen-dining room from the living area. Wainscotting and blue-print wallpaper establish a country motif. Floor-to-ceiling ash cupboards line the walls of the kitchen and dining area, providing plenty of storage space.

More Room, Less Heat Costs

Moving from a double-wide trailer to the 2,976-square-foot house was a big change for the Bramlettes and their three children, but the move has been worth it, both for low energy costs and comfort. "We're heating about 1,500 square feet more than before," Susie said, "and our highest heating costs are easily 60 percent less than they were in the trailer."

Part of the RCDP agreement is that the Bramlettes will report their weekly heat usage. "We quickly see when we're being foolish with our electricity use," Tom said.

The house performs year-round. "In the summer, the house's construction helps to keep it cool," Tom said. "We close the draperies and windows and the house stays comfortable even though it may be in the 80s or 90s outside. We also like the quiet afforded by the extra insulation. We can sit in the house and see the trees bending, but we can't hear the wind." □

Late afternoon sunlight entering the south-west-facing windows warms the living area. The lighting design reduces the number of ceiling fixtures that might contribute to leaks through the air-vapor barrier.

Lessons Learned

Mediterranean design and rooftop solar panels hint that Roy Cornell's house may be a bit out of the ordinary for a Montana farmhouse. It is. Roy, Dillon fire chief and a farmer, is well known for his interest in energy-saving techniques and his house and shop reflect that fascination. Over the years he's learned some lessons, which he's willing to pass along to others.

The rooftop solar collector on Roy Cornell's house delivers hot water to a radiant floor heating system. It is just one of Roy's techniques for saving energy.

Owner
Roy Cornell

Location
Dillon

Designer and Builder
Owner

Style
1 Story with Basement

Insulation
Ceiling · R44
2 x 6 Wall · R27.5
Basement Wall · R21

Square Feet
Main · 2,500
Basement · 2,500

Special Features
Active Solar
Hydronic Heating

Heat
Gas, Solar, Wood

Completed
1979

Calculating Heat Loss Helps Design

"First, figuring heat loss early in the design of the house made me think of each window and door as a hole in the wall and every outside wall as a heat sink to the outdoors. It influenced me to use more insulation, tight caulking, fewer skylights, thicker glazing, and even to modify the floor plan.

"Although I measured every square foot of wall and window area and cracks to get the heat loss, a more streamlined method in the guides issued by the Hydronic Institute or a computer program by Montana Power will give about the same figure with less time-consuming detail. Under worst conditions—a minus thirty-degree outside temperature with a 15 mph wind—my heat loss calculation came to 51,800 Btu per hour. The other two methods showed 54,900 Btu per hour."

Tight Construction

From full basement to the red mission-tile roof, the house was built to fend off nature's extremes. The exterior of the 6-inch-thick concrete basement walls was painted with a waterproof coating and sheathed with extruded polystyrene insulation (1 1/2-inch thick down to 4 feet, then 3/4-inch thick down to the 8-foot-deep footings). A waterproof plastic membrane was installed over the polystyrene.

Backfilling of soil next to the foundation was done in 2-foot-deep increments. After each layer was placed, it was soaked with water and allowed to settle thoroughly before the next layer was added. The finished grade slopes away from the foundation, and a 3-foot roof overhang drops rain and snow away from the house. The interior concrete basement walls are furred with 2 x 4 studs, then filled with foamed-in-place urethane. Drywall was installed on the interior. The concrete floor lies on a 6-inch layer of gravel.

The framed 2 x 6 walls on the main floor, from inside to out, consist of 1/2-inch drywall, 6-mil polyethylene air-vapor barrier, 5 1/2-inch fiberglass batts, 1-inch foamed-in-place urethane, 1/2-inch plywood, felt paper, and 3/4-inch concrete stucco.

A foot of cellulose insulates the ceiling to R44. Windows are vinyl clad Andersen with triple glazing. Reflective Verosol shades help in controlling heat gain and loss through the windows.

Active Solar Considerations

Roy chose to include active solar as part of his heating system because he likes to use renewable resources. "But," he said, "an active solar system for space heating shouldn't be a priority. Even if a person builds it himself, the system may never pay back at current utility rates. I put $10,000 into the materials for solar heating. If someone else had installed the system, the cost would have doubled. I did get a tax credit at the time, though." Besides the initial cost of the system, the total cost was increased by materials and labor needed to correct some malfunctions, which Roy said people should be aware of if they are contemplating an active solar system.

Solar Heat

The solar system incorporates a 600-square-foot site-built roof collector, glazed with twenty-seven 34- x 90-inch insulated patio door blanks. The collector surface is 80 feet long, 8 feet wide, and slopes at a 55-degree angle on a modified roof truss designed and built on the site. The collector has approximately 10,000 feet of tubing, 480 tubing connections, and over a ton of glass in it.

Within the solar collector, a 50-50 water-glycol solution circulates through black 1/4-inch neoprene-type tubing. The tubing is connected to vertical copper manifolds.

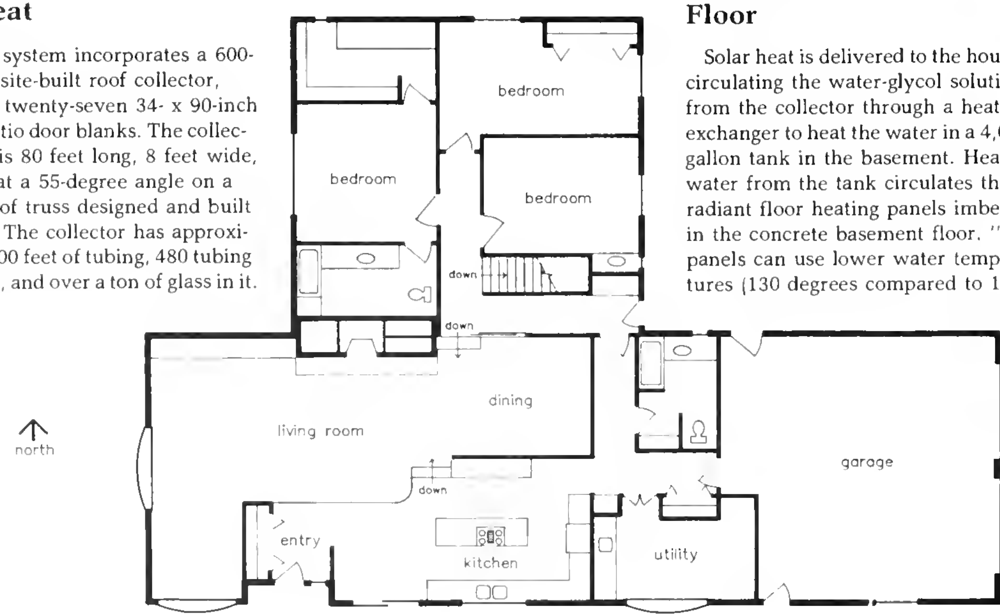
Malfunction Corrections

"Virtually all of the problems with the solar system relate to the tubing connections and the weight of the glass," Roy said.

The first problem in the system occurred in the "sleeves" which connect each tiny neoprene tube to a hole punched in the copper manifold. "The sleeves were supposed to be Teflon," Roy explained. "But to save money, the distributor made his own from tubing sold to him as Teflon, but which was plastic. One day the power went off. The liquid boiled out of the tubing, causing the collector to overheat and melt all of the plastic sleeves."

The sleeve damage let the water-glycol mixture circulating through the tubing escape and vaporize, leaving a whitish dust on the black neoprene tubing. "I made sleeve replacements from copper tubing," Roy said. "Although it still works, the lighter color reduces the amount of heat absorbed by the collector," Roy said.

A second problem occurred in the frame. "I underestimated and built the frame too light to support the weight of glass and the expansion and contraction movement from heating and cooling," Roy said. "This created air leaks and dust accumulation, which also reduced the efficiency of the collector."

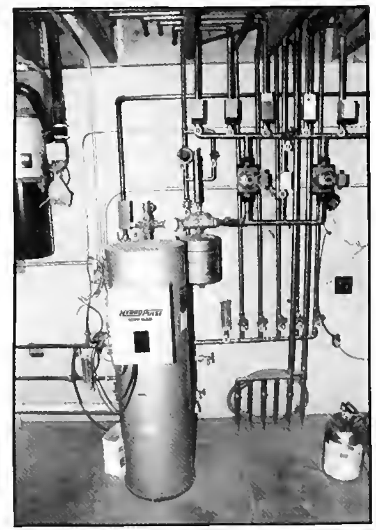


Solar Warms Basement Floor

Solar heat is delivered to the house by circulating the water-glycol solution from the collector through a heat exchanger to heat the water in a 4,000-gallon tank in the basement. Heated water from the tank circulates through radiant floor heating panels imbedded in the concrete basement floor. "Floor panels can use lower water temperatures (130 degrees compared to 190 degrees) than either ceiling panels or baseboards can," Roy said.

Remodeling the Heat Exchanger

Reading and research during design and construction led to some changes in all areas of the project. One change replaced the heat exchanger between the collector fluid and the storage tank water. The original plan used 320 feet of 1/2-inch iron pipe welded inside the storage tank. The hot fluid from the collector was circulated through this pipe.



Eight pumps circulate the fluid through the hydronic heating circuits. The heating system and solar collector each use 2 pumps in parallel and will continue to operate if one pump fails. All components—pumps, valves, controls, thermometers, and so on—are labeled and their functions listed in an "owner's manual."

The stone fireplace is an integral part of a hydronic baseboard system. At the left end of the fireplace, wood panel doors conceal a wood elevator. A cable and pulley complete with limit derail, and door interlock safety switches lift the elevator from the basement to the fireplace.

Roy decided to build two tube-and-shell exchangers, both using copper pipe and fittings, to fit into the available space and the existing plumbing layout. "More heat is now being transferred in 7 1/2 feet of tube-and-shell exchanger than ever was in 320 feet of interior pipe," he said.

Hot Water Preheat Loop

The storage tank also preheats the domestic hot water. A 160-foot loop of 1/2-inch copper pipe and a manifold are mounted on plastic insulators in the top few inches of storage tank water. "All connections to the tank, inside and out, were made with insulated dielectric unions to avoid electrolysis resulting from dissimiliar metals' contact with one another," Roy said. "Water from the well flows through this loop on its way to an electric water heater."

Hydronic Baseboard System

In addition to the solar space-heating system, Roy installed a gas-fired hydronic baseboard system with a fireplace water grate added. A Hydro-Pulse boiler is the heart of the hydronic system. "About 10 percent of the energy in natural gas goes out with the steam you see coming from the chimney when the outside temperature is below zero. The only way to salvage that heat is to condense the water vapor, which this boiler does," Roy said. Because most of the heat is removed from the exhaust gases, those gases are cool enough to be vented through a 1 1/2-inch plastic pipe. Spark plug ignition removes the need for a standing pilot light.

Roy increased the length of the baseboards to compensate for a water temperature of about 135 degrees (compared to the usual 190-degree water in standard baseboard heater designs). "The system is about 94 percent efficient," Roy said. "My winter gas bills average between $20 and $35 a month.

"In 1986 I cleaned the spark plug and put in new valve reeds. The manufacturer suggests this be done every 5 years; mine went 7. That's the only maintenance it has needed."

Zoned Heat

The baseboard radiators in the house are divided into four heating zones so heat is sent only to where it's needed. Each zone has a valve that controls the flow of hot water to that zone. A fifth zone valve delivers heat to a central humidifier to supply warm humid air during dry winter days. This unit is controlled by a humidistat.

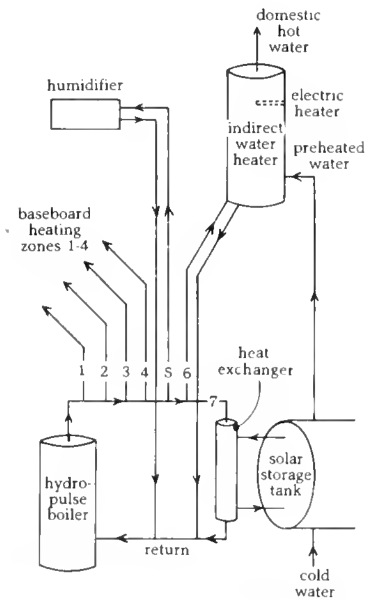
A sixth zone valve circulates hot water to a coil of copper pipe in the bottom of a domestic water heater. "This lets the high-efficiency boiler heat the water most of the time," Roy said. "The upper electric element is active only when we use a lot of hot water."

Fireplace Plays a Part

A 14-foot-long stone fireplace on the main floor is integrated into the heating system. The 40-inch fireplace combustion chamber features airtight glass doors, smoke damper, outside air for combustion, and fan circulation of warm air. Ashes can be dumped directly from the combustion chamber to a large ash bin in the basement which can hold several years' ashes.

Roy placed the fireplace on an interior wall to reduce heat losses to the outside and to accommodate other functions. In

Hydronic Heating System

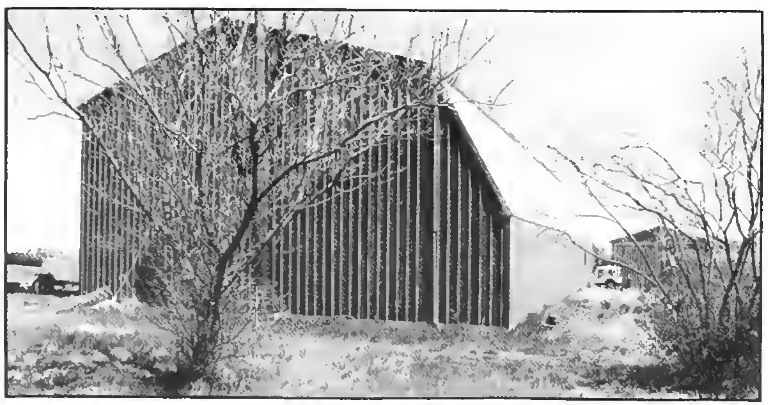


one side of the chimney is a large space that serves as a fresh air plenum from the attic to supply the combustion air for the boiler and fireplace. Furnace filters screen dust out of the air moving through this passage.

A ladder in the opening gives access to a fan motor and water grate piping. To reduce the noise from the Hydro-Pulse boiler, the boiler's exhaust is imbedded in masonry all the way to the top of the large chimney. A 2-inch rigid conduit in the chimney provides a sturdy TV antenna mounting. The conduit also serves as a direct route for antenna wiring to a television signal distribution amplifier in the boiler room. Wiring from the amplifier leads to nearly every room.

Wood-fired Heat

Boiler water can also be heated by the fireplace. A circulation pump in the return line to the boiler circulates water to the water grate in the fireplace. The grate contains over 240 feet of 1/4-inch wrought iron pipe. The pump is controlled manually by a switch on the fireplace, or by a thermostat mounted in the fireplace hood. Since the fireplace is an uncontrolled heat source, a seventh zone valve feeds hot boiler water to a heat exchanger that dumps heat into the 4,000-gallon solar storage tank if the other 6 zone valves are satisfied and closed.



A bank of transluscent panels on the south side of the shop acts as a solar collector to heat the shop.

Energy Savings at the Shop

Saving energy isn't confined to the house. An extension on the south side of Roy's shop made room for a second story attic solar collector. "It can be below zero at night. So long as the next morning is clear and sunny, the solar area will be warm enough to work in by 8:00 or 9:00 a.m. By 10:00 I have to move to the main shop area to get out of the heat," he said.

Roy adapted the idea from an Extension Service plan, "Solar House Design." The inexpensive double-layer solar glazing is made from corrugated fiberglass panels and Monsanto 602 ultraviolet temporary greenhouse glazing. "I stretched the 602 when it was warm and got it too tight. At minus 40 last year it popped. But, it's easy to replace and the fiberglass didn't cost any more than the sheet metal siding I would have had to use," he said.

A used washing machine motor and blower move heated air from the solar collector to the shop. "I turn the motor on at 9:00 as soon as the sun warms the collector. The shop is comfortable by 10:00." To help retain the heat in the shop, Roy built the walls of 2 x 6 studs and packed them with fiberglass insulation and insulated the ceiling. The shop's concrete floor holds heat and lets the shop coast through the night without freezing.

Other Useful Features

Aside from the energy-saving aspects of his house and shop, Roy incorporated several features to save time and avoid problems.

— Certain electrical circuits are wired through a smaller load center and transfer switch so a standby generator can take over if power is interrupted.

— Secondary drains under the washing machine, dishwasher, and relief valves on the solar collector, solar storage tank, hot water heater, fireplace loop, boiler, and well water system drain to a visible drain in the basement, so Roy is aware if a problem is occurring.

— An insulated domestic hot water circulation loop from the water heater keeps hot water at every faucet without large standby heat losses.

— A 12-volt outdoor lighting system, run off a transformer, can be turned on from several inside switches.

— Photoelectric cells control six nightlights throughout the house.

— Heat cables on roof valleys keep ice from forming.

— Sewer cleanouts are located outside the basement wall and in strategic areas inside. No drain has more than one 45-degree horizontal bend to the septic tank.

— Two septic drain fields were installed with a Hancor alternator valve that switches the effluent from one drain field leg to another, and with two air stacks which pull oxygen through the drain fields to hasten the aeration.

It's impossible to detail all of Roy's energy-saving devices here, but he said he'd be willing for interested people to contact him. □

"Little Tract House" Saves Energy, Provides Comfort

Living in a drafty trailer for two years persuaded Greg and Linda Hansen that they needed a comfortable, energy-efficient house. The Hansens are a working family with two school-age children, and funds for the new house were limited. They set about building a house they could afford on their wooded land northwest of Eureka, promising themselves that they would build for comfort and livability, but installing only the energy-efficiency features that could pay for themselves within five years.

The result, according to Greg Hansen, was "a little tract house" that nicely meets the Hansens' goals for economy, comfort, and energy efficiency. The house is single-level, 28 x 36 (1,008 square feet) on a concrete slab with no basement. Outer walls are single thickness, built with "advanced framing" (see Glossary) using 2 x 8 studs on 24-inch centers. Only 87 studs were required.

Insulation from Footings to Attic

The slab was poured in one piece with a 6-inch-thick concrete foundation extending 3 feet below grade. The foundation is insulated on the outside with 3 inches of extruded polystyrene, and has a 6-mil polyethylene moisture barrier on the inside surface. The outer 4 feet around the perimeter of the slab are insulated with 1 inch of extruded polystyrene placed under the concrete. The ceiling is insulated to R55 with 15 inches of blown-in cellulose. The blocks between the studs in the exterior stud walls are nailed flat to the wall rather than completely blocking the space between the studs. This is called "ladder blocking" (see Advanced Framing in Glossary). Ladder blocking leaves the wall cavity open so that insulation can be blown into the wall from the attic through holes in the upper plate. This construction provides continuous insulation from the bottom of the wall into the attic. The raised-heel rafter trusses leave room for this insulation over the exterior stud walls. The 7 1/2 inches of cellulose in the walls have an insulating value of about R28. Before the windows are installed, insulation is blown into the spaces above and below the window openings. This insulation enters the spaces through holes drilled for the purpose in the upper plate above the opening, and through the window sill plate. The walls and ceiling are finished with 5/8-inch gypsum board installed in an "advanced drywall" configuration (see Glossary). The walls are painted with vapor barrier paint.

Argon Windows Beat Triple-pane

The house has no really large windows, but four small-to-medium windows on the south side allow some

The Hansen house is a comfortable, modest family dwelling with low energy bills

Owners
Greg and Linda Hansen

Location
Northwest of Eureka

Designer
Owners

Builder
Greg and Linda Hansen
Box 1168
Eureka, MT 59917
889-3715

Style
1 Story on Slab

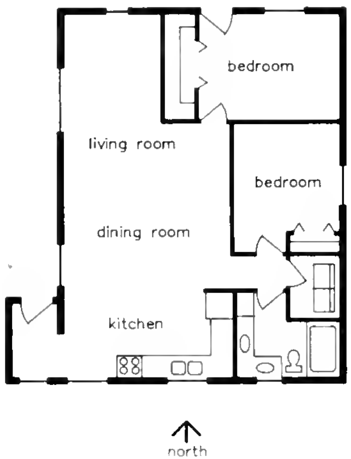
Insulation
Ceiling - R50
Walls - R28
Slab - R5
Foundation - R15

Square Feet
1,008

Special Features
RCDP Construction
Argon-filled Double-pane Windows
Advanced Drywall Approach
Air-vapor Barrier
Advanced Framing

Heat
Passive Solar, Electric Fan-forced Heaters, Ventilator Duct

Completed
October 1986



passive solar heating of the living space. Solar heating during the "low sun" winter period is limited by the surrounding forest which is cut back enough on the south side of the house to allow sun to shine on the house for at least a little while during clear winter days. All the windows in the house are standard Crestline double pane, except the two windows on the north side, which have argon gas between the panes. The argon raises the R-value of the windows from about 2 to about 4.5. This makes the argon-filled windows better insulators than standard triple pane windows, which have an R-value of about 3. Double-pane argon windows cost less than standard triple pane windows of the same size. On the chilly winter day that DNRC visited the Hansen house, the Argon window was noticeably warmer to the touch than the standard double pane next to it.

Electric Heaters Supplement Solar Warmth

Heat sources in the house besides the sun include four electric fan-forced wall heaters and an electric resistance heater in the duct of the VanEE 2000 heat recovery ventilator that controls the indoor air quality. The total Btu capacity of the wall heaters is approximately 19,000, with another 3,400 in the duct heater. When the temperature of outside air drops to 40 degrees, the duct heater turns on to warm the incoming air. The water heater, cook stove, and all other appliances in the home are operated with electricity, but are metered separately from the heater. Greg said monthly winter electrical bills run about $85. The Hansens' metered heat bill from January 1, 1987, to January 1, 1988, was $165.56.

Greg alternates working a night shift part of the time and is home during the day, so the indoor temperature is maintained at a comfortable level during all hours. They do not set the thermostat back at any time of day.

The Hansens did most of the construction themselves, so cost was limited to about $30,000. Greg said a construction contractor probably would charge $38,000 to $40,000 to build a similar house in the same area.

The inside of the Hansen house is spacious and well-lighted.

Roomy, With a Low Profile

When Sam and Sherry Richardson were considering building an energy-efficient house, they decided to use the natural terrain to protect them from the northern Montana weather. With this in mind, they went just north of the town of Fort Peck and bought a lot that had what they needed: a high, south-facing slope to shelter them from the north wind. At the foot of this slope they dug a hole and began building their underground house. The Richardsons also built an attached, earth sheltered 24 x 24 foot garage. Roomy at approximately 2,000 square feet, the Richardsons' single-level house blends nicely into the landscape.

A bench to the north helps shelter the Richardson house from northern storms.

Owners
Sam and Sherry Richardson

Location
Fort Peck

Designer
Don Metz
Lyme, NH 03768

Builder
Owners

Style
1 Level Underground

Insulation
Roof - R30
Stud Walls - R38
Concrete Walls - R20 R10
Slab - R10

Square Feet
2,000

Special Features
Underground
Plenum Between Two Concrete Floors

Heat
Passive Solar Wood, Electric Furnace

Completed
October 1987

Sound and Underground

As usual with earth-bermed dwellings, the outer structure of the Richardsons' house is mostly concrete. The rear wall and sidewalls are 8-inch reinforced concrete. The floor is 4-inch concrete over an 8-inch air space with another 4 inches of concrete below it. The air space between the slabs is designed to be used as a plenum in heating the house. Two inches of extruded polystyrene insulates the underside of the lower slab.

A Roof of Wood and Dirt

The roof structure is all wood, with no concrete. The structural strength of the roof is in the 6 x 10-inch rough-sawed pine timbers, placed 16 inches on centers and supported by inside bearing walls. Steel I-beams provide support over doorways. The maximum span supported by the timbers is 13 feet 7 inches.

Sam Richardson on his roof with the shade he invented that can be tipped to keep direct light out of his skylight in the summer and admit it in winter

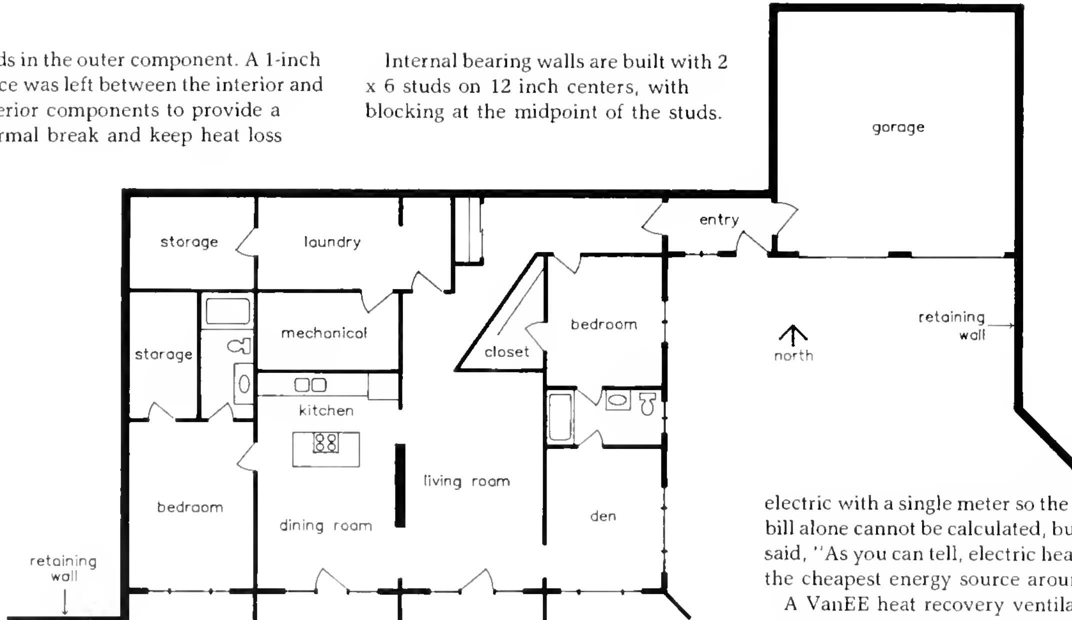
The roof structure over the beams consists of 2 x 6 inch tongue-and-groove roof decking with a layer of Bituthene waterproof membrane over the decking, and then three 2-inch-thick sheets of extruded polystyrene. Eighteen inches of dirt over the polystyrene completes the roof. Inside the house, a suspended ceiling was installed below the support timbers.

Double Walls, Well Insulated

The above-grade exterior walls on the south and east are double walls, built with 2 x 6 studs on 12-inch centers in the inner wall component and 2 x 4

studs in the outer component. A 1-inch space was left between the interior and exterior components to provide a thermal break and keep heat loss

Internal bearing walls are built with 2 x 6 studs on 12 inch centers, with blocking at the midpoint of the studs.



through the walls at a minimum. The walls were insulated with two layers of R19 fiberglass batts. The upper 4 feet of the foundation under the exterior stud walls is insulated on the outside with 4 inches of extruded polystyrene, with 2 inches of the same material extending below that to the footings. Below-grade concrete walls also are insulated with 4 inches of polystyrene on their top 4 feet and 2 inches from there on down. A 4-mil polyethylene air-vapor barrier was installed under the drywall on all exterior walls. All edges and openings in the air-vapor barrier were sealed with caulk. Sam said he didn't think an air-vapor barrier was necessary in the ceiling because of the waterproofing in the roof immediately above the ceiling and the 6 inches of insulation and 18 inches of dirt above the membrane.

Warming With the Sun, and Electricity

The large windows on the south side let in enough sunlight to keep the house warm in most weather, and a 63,000 Btu Sears electric furnace provides additional heat when needed. A "Vigilant" wood stove from Vermont Castings provides a source of radiant heat. The wood stove is next to a decorative brickwork arch that provides a focal center for the living room and kitchen. Combustion air for this stove is piped in from outside. Sam said he fires up the wood stove for a couple hours in the evening when the weather is cool.

The Richardsons moved into their house in October, and their electric bills in the following three months were: November, $45.36; December, $64.33; and January, $92.60. The house is all-electric with a single meter so the heat bill alone cannot be calculated, but, Sam said, "As you can tell, electric heat is not the cheapest energy source around."

A VanEE heat recovery ventilator controls indoor air quality. For cooling, a thermostat operates the furnace fans without the heating element when indoor temperatures rise to a preset level. A 2 1/2-foot overhang keeps the summer sun from entering the windows and overheating the house. Drapes on the windows reduce heat loss during cloudy periods and at night.

Double-pane Windows, Insulated Doors

The windows are Andersen double panes. Outside doors are Therma-Tru foam-core metal with magnetic-seal weatherstripping. One feature unusual for an underground house is a skylight that brings natural light into the rear portion of the living space. Sam invented a louvred shade that can be tipped one way in winter to let light into the skylight, and tipped the other way in summer to keep direct light out.

Did It Themselves

The Richardsons cut their construction costs by doing most of the work themselves over a six-year period. They estimate that a professional building contractor would require about $80,000 to build a similar house in the Fort Peck vicinity. The most critical part of the structure, the roof, has been in place for three years and has not leaked.

So far, the Richardsons are happy with their house, and wouldn't make any radical changes if they were building it again. Although, Sam said, he would place the retaining wall next to the garage differently, because where it is now it stops snow in the driveway. □

Unfinished ceiling shows heavy beams in roof structure. Note steel I-beams extending left and right from brickwork arch.

Sun Tempered and Superinsulated

Hugging the slopes of Edith Peak west of Missoula, Jerome and Yvonne Coopmans' 40 timbered acres will remain as shelter for deer and other wildlife. Jerome Coopmans isn't about to use the trees for firewood. "My friends say, 'You have all this wood, why don't you have a wood stove?'. Well, I don't like the mess and I can use my time in better ways than gathering fuel."

Instead of a home heated with a wood stove, Jerome and his wife, Yvonne, built an all-electric house that takes very little energy to heat. During the 1986-1987 winter, their total electric bills ranged from a high of $124 during a particularly cold November to only $70 in March.

Yvonne estimates they spend $25 a month for heating water, $8 for drying clothes, and $20 to $30 for cooking and operating other appliances and computers. "In our last house just 7 miles away, the electric bill averaged between $50 and $60 a month. We burned wood to heat the house so none of that money was for space heating. Of course, this house is so well insulated, the heat generated by our appliances reduces the need for space heat," Yvonne said.

Yvonne Coopmans

Garden windows on the south and west of Jerome and Yvonne Coopmans' house bring plenty of daylight into the basement recreation room and den. Tall windows in the second floor living room and third floor office capture the view and the winter sun's heat. A dining area on the sunny southeast corner of the house (right) overlooks the Bitterroot Range and the Clark Fork. A door to the wrap-around deck encourages dining outside.

Proportional Thermostats Promote Comfort

A total of 5,500 watts of baseboard heat has kept the Coopmans warm even at minus 20 degrees. "We keep the thermostats at 72 degrees and make no effort to lower them at night," Jerome said.

"We have small 350 to 650 watt electric heaters in nearly every room, with a 1,000 watt heater in the recreation room on the ground floor, where the primary winter entrance is located. Each area has its own thermostat, most of which are Intertherm proportional line voltage thermostats. These thermostats have many advantages over the conventional bi-metallic ones. Since the thermostat kicks the heater on and off every few seconds, the heater doesn't cycle from cold to hot to cold; it's always at exactly the correct temperature to make up for the area's heat loss. The continuous pulsing on and off eliminates the crackling noise often made by baseboards, and the heaters seldom get very hot, so they're safer."

Insulated Foundation and Slab

Jerome pointed out the construction that makes the house so efficient. The 8-inch concrete foundation walls are

Owners
Jerome and Yvonne Coopmans

Location
Frenchtown

Designer
Owner, Builder, and
Jonathan Qualben
618 South Second West
Missoula, MT 59807
543-5033

Builder
Owner and Southwall Builders
644 South Second West
Missoula, MT 59807
549-7678

Style
3 Story

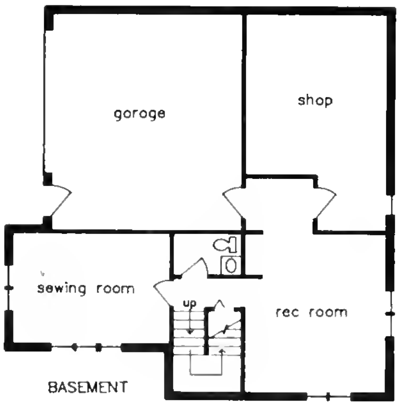
Insulation
Ceiling
Second Floor - R60
Third Floor - R70
Double Walls - R38
2 x 6 Wall - R28
Garage
North and West Walls - R16
South and East Walls - R29
Basement
Stem Walls - R27
East and West Pony Walls - R36
South Pony Wall - R29
Slab - R5

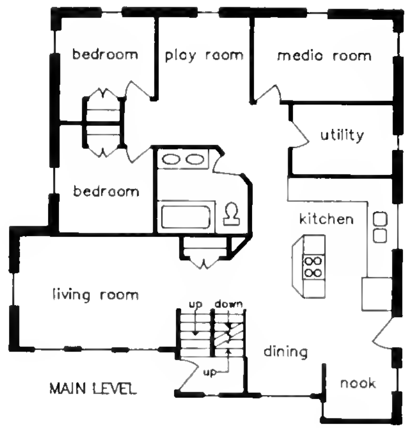
Square Feet
Loft - 635
Main - 1,366
Basement - 718

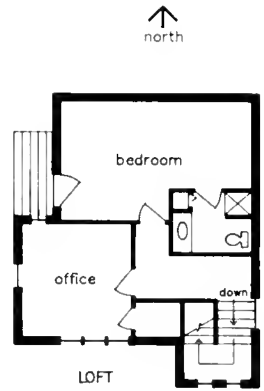
Special Features
Airtight Drywall
Proportional Thermostats

Heat
Electric Baseboard

Completed
December 1986







sheathed on the outside with 1-inch extruded polystyrene insulation. The north wall is embedded in the ground; the south, east, and west stem walls are bermed. All basement concrete walls are furred out and insulated with blown-in-blanket (BIBS) fiberglass insulation. The double-thickness pony walls are framed with two 2 x 4 stud walls with a 2-inch space between the inner and outer stud walls. BIBS insulates the cavities.

Insulated overhead doors and 2 x 4 outside walls with R11 fiberglass batts help moderate temperatures in the garage space on the northwest corner. "It was 6 degrees here the other day; the temperature in the garage didn't drop below 48 degrees," Jerome said.

The garage ceiling is insulated from the living area above by R38 BIBS. To stop air infiltration, rim joists in the garage are sprayed with BIBS using extra binder. "BIBS is fluffy like cotton balls and has a lot of trapped air space which brings its R-value to 4 per inch," Jerome said.

Heat is prevented from escaping to the ground by 1-inch extruded polystyrene foam board under the basement slab. A 1-inch layer of sand lies between the foam board and the slab. The foam board was placed over a TuTuff polyethylene moisture barrier which lies over a 2-inch layer of sand. "I think many houses have moisture problems because the ground vapor wasn't sealed out properly," Jerome said.

Double Versus Single Walls

Jerome framed the south side of the second and third levels with a 2 x 6 single wall, sheathed with 1/2-inch waferboard and 3/4-inch polyisocyanurate foam board beneath the siding. The west, north, and south walls are double stud walls with waferboard installed as an air barrier beneath the siding. Seams between the waferboard sections were taped with mylar.

"If I had it to do over, I'd use all double walls," Jerome said. "The electric cooperative's computer said that the 2 x 6 wall on the south would be just as effective as the double stud walls, and it probably is. But I didn't save any money, and the framing would have been easier if the walls had been all the same. Besides, I like the deeper window sills. I can set my coffee cup on them."

Airtight Drywall

Instead of using a polyethylene wrap, Jerome applied airtight drywall to form the air-vapor barrier on the interior of the house. Neoprene gasketing stops air and vapor movement between the framing and the drywall, between the top and bottom plates, and between the partition walls. "We used acoustical sealant in some places because we ran out of neoprene gasketing," Jerome said. "The drywall seams were sealed when they were taped and mudded by the drywallers. We applied one coat of low-permeability primer and one coat of low-permeability paint over the drywall to complete the air-vapor barrier." Jerome used 5/8-inch drywall for a sturdier mass against the knocks it can receive from children and to obtain greater thermal mass.

Rim Joists

The rim joists presented a particular problem and Jerome has some advice for others who are building. "Rim joists can be real leaky if you don't insulate properly," he said. "Boards are not perfect; many have small warps or other irregularities. I used 1/4-inch Sill-Seal foam gasketing on the rim joists, but it didn't fill some of the gaps. Perhaps 1/2-inch would have worked. So, to stop air and vapor movement, we caulked the rim joist between each floor joist with silicone and closed the top opening between the two stud walls with a small piece of extruded polystyrene foam board and caulked it. This required a lot of extra work. I should have 'S'-wrapped TuTuff over the rim joists and around the sole plates." (See diagrams.)

Tightening the House

All rough wiring was installed before the walls were insulated with BIBS. Jerome used globs of silicone to caulk wire penetrations of the air-vapor barrier. The silicone remains flexible and will stay in place during wire movement when he finishes the outlet wiring. He chose plastic outlet boxes because they seem to have fewer leaks and holes than metal boxes. The boxes are caulked tightly to the drywall. Yvonne said that a good method to check caulking is to shine a flashlight from behind the caulking after dark. "You'd be amazed at how many pinholes show up," she said, adding, "of course, this doesn't work with clear caulk."

All windows are double-glazed Clawson windows with low-E film. Only three windows penetrate the cooler north side of the house.

Lighting Saves Penetrations

Lighting was planned to minimize the number of holes in the drywall air-vapor barrier, and the consequent need to caulk to maintain airtightness. The Coopmans have no recessed lights. Exterior can lights, track lighting, and wall lighting predominate. In the kitchen, a large

fluorescent fixture with "warm" tubes provides plenty of illumination.

Air Quality Concerns

The Coopmans' heat recovery ventilator hasn't been installed yet. Its duct heater is being modified to work with an Intertherm proportional thermostat. Jerome also wanted to find out what the air quality would be without a ventilator. "We purposely provided several sources of air infiltration estimated at one-tenth of an air-exchange per hour. These sources, combined with the occasional use of a 500 cubic-foot-per-minute range ventilator in the kitchen, did an adequate job of maintaining air quality, except for the bathrooms," he said. "The bathrooms were ducted to the ventilator and hence did not receive sufficient ventilation. When it was real cold, we got a tiny bit of condensation on window corners.

"Although the ventilator will be installed soon, I believe we could have used exhaust fans with programmable timers to dump inside air, which would have been much simpler and less expensive," Jerome said. "Other factors such as building materials that give off formaldehyde fumes, the presence of radon, the quantity and types of indoor plant life, are important in determining indoor air quality control. Hobbies that use noxious chemicals should be confined to the garage or outdoors."

The plan for the air exchanger is to discharge one-third of the fresh heated air into the first floor and let it filter upstairs. The rest of the fresh air would go directly to the boys' bedrooms and play area on the second floor and to the master bedroom on the third floor. Stale air intakes are in the bathrooms, the utility room, and above the cabinets in the kitchen.

Insulated Water Heater and Bathtub

In their quest for energy savings, the Coopmans didn't overlook their water heater. They selected a Sta-Kleen 52-gallon heater with a tank insulated to R17 and installed it on an R15 insulated pad.

"We also ran 3/4-inch pipe from the room containing the heater to the roof so solar water preheating could be easily added," Jerome said.

In the main bath, Jerome installed R30 insulation around the bathtub to make hot baths last longer.

Extras About 10 Percent

Jerome estimated the total cost of extras for energy features, such as the heat recovery ventilator and ducting, extra framing for double walls, extra insulation, and gasketing and caulking on the drywall, amounted to 10 percent of the total cost of the house.

Computers Play Central Role

Extensively wired for electronic gear, a media room full of equipment attests to Jerome Coopmans' job and hobby. Jerome writes software for Percon Inc., a firm where he is also a partner.

Computers, printers, disks, and piles of technical manuals occupy every inch. These computer activities spill over into Jerome's third-floor den adjacent to the master bedroom. Because the R70 insulation over the vaulted bedroom ceiling and the heavily insulated walls retain the heat generated by the computers and peripherals, no auxiliary heat is required on the third floor.

The distractions of his work added to the time it took Jerome to build his house. But his education and training contributed to the home's livability and energy-efficiency. "We spent hundreds of hours figuring out rooms, the central air delivery and pickup, windows, walls, and so forth," Jerome said. "But it was worth it. The whole house works. We are very pleased with its thermal performance." □

Yvonne Coopmans

Sleek European kitchen cabinets offer a wealth of shelf and counter space, and their clean lines afford easy cleanup and maintenance. Airtight drywall with special paint prevents warm, moist air from migrating into wall cavities.

Apart From the Crowd

Owner
Jonathan Jennings

Location
Gallatin Gateway

Designer and Builder
Jonathan Jennings
Mountain Home Builders
185 Little Bear Road West
Gallatin Gateway, MT 59730
763-4324

Style
1 1/2 Story

Insulation
Ceiling - R60
Double Wall - R40.5
Stem Wall - R22.5
Slab - R22.5

Square Feet
Upper - 600
Main - 1,200

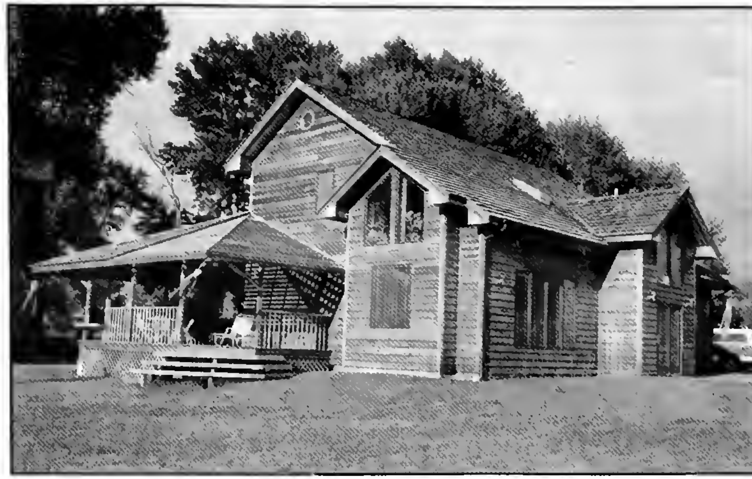
Special Features
RSDP Construction
Thermal Storage
Advanced Framing

Heat
Passive Solar, Electric Baseboard

Completed
April 1985

White stucco walls and ceiling, windows set in thick walls, and a tile floor give Jonathan Jenning's house the aura of a Spanish mission. Shafts of sunlight from the peaked 2-story high windows saturate the spacious interior with warmth and light.

The plain white decor is embellished with colorful Tibetan carpets, and accented by comfortable rolled-arm couches and chairs upholstered in heavy fabric of blue and maroon. Ferns and ivies cascade from high window ledges, and numerous pots of tropical greenery lend their textures and tones to the airy living space.


Jonathan Jennings

A traditional covered porch belies the high technology features of the house. To test new techniques for lowering energy use, Jonathan Jennings built his country house to meet the specifications of the Residential Standards Demonstration Program.

Sunspace Part of Living Area

The house's comfortable liveability results in part from its carefully crafted energy efficiency. The sun is a full partner in the warmth of the Jennings house. "I couldn't afford a sunspace as a separate room, so I brought it into my living area," Jonathan said. A concrete slab beneath the living area soaks up heat from the sunlight pouring through the south-facing windows. The tile floor's dark gray color helps absorb the sun's heat. Two-inch polyisocyanurate foam board under the slab and 3 inches on the stem walls hold in the warmth.

The Pella windows also are designed to hold in the heat. Double glazing and low-E film in the windows slow the passage of heat to the outside. Venetian-type Slimshade blinds between the two panes of glass are coated with a film to reflect radiant heat indoors. Ceiling paddle fans circulate warm air back to the living space in winter, and in summer they exhaust warm air through opened windows.

The cooler rooms—airlock entry, utility, hall, baths, and bedrooms—are located on the north side. Glass blocks incorporated in the center wall separating the south-facing living space from the north rooms provide a pathway for light into the hall. "For me, natural daylight is one of the most comfortable features in any house," Jonathan said.

Jonathan pointed out the VanEE-R200 heat recovery ventilator in the utility room. "Although I spend about 40 minutes a week pouring 10 gallons of water into my plant collection," he said, "I really don't have any window condensation problems." The ventilator runs for two minutes every half hour, bringing in fresh air and expelling moisture-ridden stale air. "Once in a while, on very cold days, I'll get a bit of moisture in the corner of one window," he said.

Peaceful Warmth

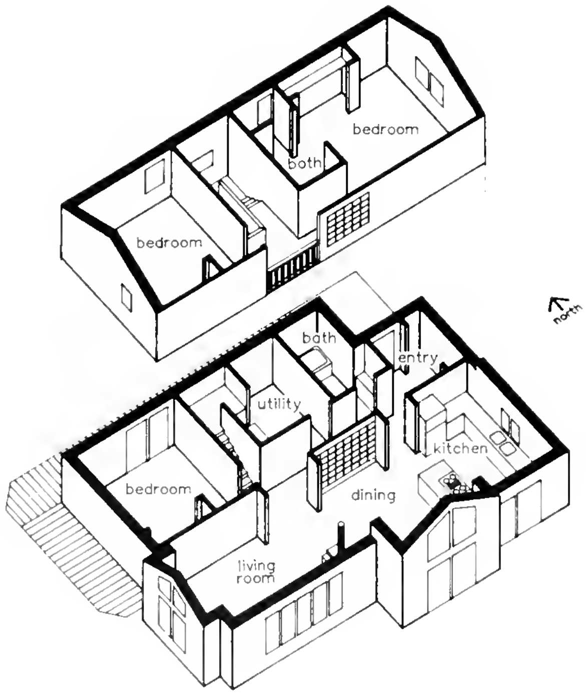
Jonathan depends on electric baseboard heat to supplement the sunlight. "In the three years I've lived here," Jonathan reflected, "I've only used three of the baseboard heaters—the two 6-foot ones in the living room and the 5-foot one in the dining room. My utility bill averages $65 a month through the winter and $25 to $30 in the summer. Even on the coldest mornings, the inside has never dropped below 63 degrees."

The wall and ceiling construction helps maintain this even temperature. In the vaulted ceiling, 8 inches of foamed-in urethane insulation and a 6-mil polyethylene air-vapor barrier stop heated air from escaping through the ceiling. Double walls hold three layers of R11 fiberglass batts. An air-vapor barrier inside the wall, and 1-inch polyisocyanurate sheathing on the exterior further tighten the house.

The house is just as comfortable in hot weather as cold. "It's incredible how an overhang keeps a house cool by keeping out the summer sun," Jonathan said. "In the summer, the house stays 20 to 25 degrees cooler than the outside."

Jonathan is impressed by the home's quiet. "The wind can be blowing a gale, but I almost have to see the trees bending to realize it. Energy-efficient construction provides not only a thermal barrier, but also a sound barrier. The house needs less cleaning than regular houses, perhaps because there's not as much dust blowing around."

Living, dining, and kitchen area share space and a view of the Gallatin Canyon and the Madison Range. Plenty of windows and a tile-covered concrete floor combine the attributes of a sunspace with the living area in the Jennings house.



New Techniques

As one of the participants in the Residential Standards Demonstration Program (RSDP), Jonathan built his house to save kilowatts. "I didn't use different materials than other houses on the market; I just used them in diferent ways," Jonathan said. "I tried new techniques and incorporated a lot of things I'd researched." Jonathan estimated it would cost around $50 a square foot to build a similar house today, not including land, septic system, and well.

New Standards

Jonathan sees new home owners drawn to energy-efficient building. "I designed an energy-efficient house for a client. Then he got wind of the real estate market being soft, so he decided to buy instead of build. After looking, he came back. Although many of the houses were going for very, very good prices, none had the features he wanted.

"People interested in energy-efficient houses have done some research and know what construction details to look for. A house with energy-saving features is not often for sale," Jonathan said. "If people want a house of this type, they usually have to have it built." ▢

Upstairs, an inset of light-diffusing glass blocks admits light to the master bedroom while protecting privacy. An archway joins the master bedroom to the dressing area without the encumbrance of doors. Strategically placed dressing room mirrors reflect the bedroom area, visually extending the space.

Wanted: Warm New House

John Campbell and his mother, Monta, lived for many years in quarters above the grocery store they ran in Gildford. When it came time for John to retire and turn the store over to younger people, he and his mother decided they wanted a new house.

Hi-Line residents don't need to be reminded about the need to make their houses fit the weather. The Campbells decided their new house should be superinsulated to take maximum advantage of the latest building technology for cold-weather climates. They got in touch with Mel Gomke, a builder in nearby Kremlin who specializes in superinsulated houses. Mel then designed and built a house to match the Campbells' needs.

Appearances are Deceiving

The Campbell house stands out as the only new house built in the little community of Gildford in quite a few years, but is otherwise modest and unimposing from the outside. To passers-by it appears to be a more-or-less ordinary single-level conventional home with daylight basement. Inside, however, it is a state-of-the-art superinsulated house. The result of superinsulation is clearly visible in the Campbells' heat bills. The bill for the first year the Campbells lived in the house, from March 1985 through February 1986, was $120.87. This total included $35.17 for November 1985, which the Campbells said was the second coldest November the Hi-Line has ever recorded. In the mild year of 1987, heat bills were even less, as follows:

The Campbell house in Gildford looks ordinary, but contains modern energy-saving technology.

January	$20.15
February	11.42
March	12.43
April	4.03
May	.67
June - September	0
October	5.94
November	13.86
December	12.80
Total	$81.30

At least one of the Campbells is normally home, so temperatures on the main level are kept around 72 degrees most of the time. The basement remains about 64 to 65 degrees, winter and summer, and requires very little heat beyond that absorbed through the west-facing windows and through the floor from upstairs.

The Road To Low Heat Bills

The road to low energy bills is lined with insulation. The Campbell house is

Owners
John and Monta Campbell

Location
Gildford

Designer
Owners and Builder

Builder
Mel Gomke
Mel's Building Service
Kremlin, MT 59523
372-3196

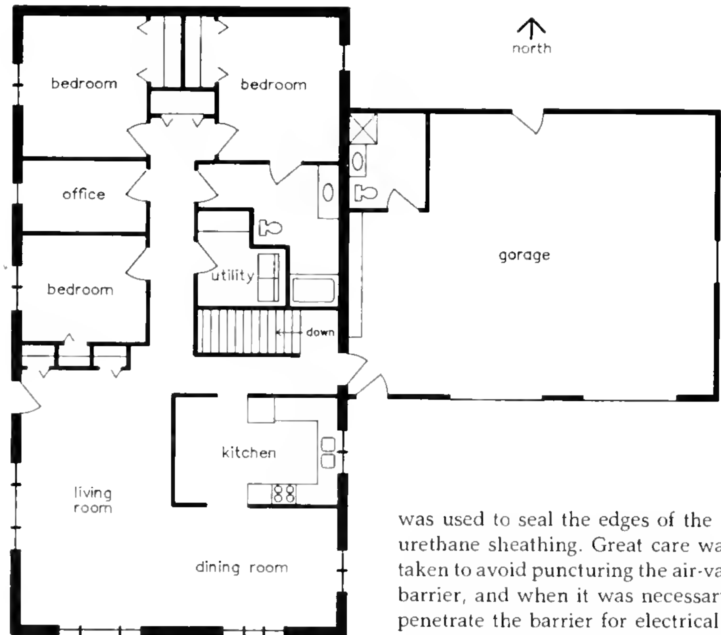
Style
1 Story with Basement

Insulation
Ceiling - R70
Double Stud Walls - R40
Basement Walls - R32
Slab - None

Square Feet
3,840, including Basement

Special Features
Wooden Basement Walls
Superinsulation
Painstaking Construction

Heat
Passive Solar, Gas



built with double 2 x 4 stud walls to make room for the large amounts of insulation that give superinsulated houses their name. The studs are on 24-inch centers and offset from each other to minimize the opportunity for heat loss through the wall. The inner and outer stud walls are 4 inches apart. Batts of fiberglass insulation were placed vertically between studs in the stud walls and horizontally in the gap between. Once the walls were complete and the insulation was in place, a 6-mil polyethylene air-vapor barrier was installed on the interior surface of the inner stud wall. A 1-inch layer of urethane sheathing then was attached over the air-vapor barrier, and the drywall was placed over this. Silicone caulk was used to seal the edges of the urethane sheathing. Great care was taken to avoid puncturing the air-vapor barrier, and when it was necessary to penetrate the barrier for electrical outlets or other fittings, the edges of the hole in the barrier were painstakingly sealed with Tremco to preserve the air tightness. Three-inch sheet rock screws were used to install the drywall. Total insulating value of the exterior walls is about R40, Mel said.

Kraft reflective foil was installed on the ceiling joists, followed by the 6-mil polyethylene air-vapor barrier and drywall. The attic is insulated with 20 inches of blown-in cellulose with an insulating value of about R60.

Tyvek was used as an air barrier on the outside of the house, with Masonite Colorlok siding for the finishing touch.

A Wooden Foundation

The house has a finished, full-sized daylight basement. The foundation walls are made with pressure-treated 2 x 8 studs on 12-inch centers, with concrete footings. The basement is sheathed with pressure-treated 5/8-inch plywood. Estimated life of this type basement is 70 to 100 years, Mel said. The walls are insulated with 8-inch fiberglass batts between the studs and 1 inch of urethane under the drywall. The joints between sheets of urethane were carefully caulked. Total insulating value of the basement wall is about R35. The rim joist is insulated with 12-inch fiberglass batts and 1-inch urethane sheeting.

A Little Gas and a Lot of Sun

To supplement their solar heating, the Campbells use a natural gas-burning Lennox 80,000 Btu pulse furnace. This furnace gets its combustion air through a pipe from outside, and vents by way of a PVC pipe through the wall. Mel said that during construction of the house, the townspeople kept wondering when the chimney was going to go in.

"If there is any sun at all, the heat doesn't come on," John Campbell said. All the windows are Andersen triple-pane low-E. The house is oriented north-south, with most of the windows on the west side. The large living room-dining room-kitchen area on the south end has windows on three sides which creates a well-lighted space with a pleasant warm feeling. The north side has no windows.

Like any superinsulated house, the Campbell residence needs a heat recovery ventilator to maintain indoor air quality. A Bossaire brand ventilator suits the Campbells' needs. They have had no problems with the ventilator. In the summer, they use the ventilator to help cool the house. The house tends to trap some heat on hot summer days, but the Campbells counter this by turning on the ventilator fan after the outside temperatures drop. This quickly fills the house with cool air from outside. When cooling needs are less, the Campbells open windows in the evening, allowing the warm air to escape and drawing cool air from the basement up to the main level. Then they close the windows in the morning before it gets hot outside. If necessary, they also close the drapes to prevent the sun from overheating the living space. No other cooling facility was installed and the Campbells say none is needed.

Taking Time to Save Energy

Only one electric light fixture penetrates the ceiling air-vapor barrier. All other lights are either installed in the walls or are drop-in ceiling tile lights. Most of the electric outlets are on inside walls to eliminate the possibility of air leaks from outside.

The treatment given to wall outlets was typical of the attention to detail that was applied in the construction. Tremco was used to seal the air-vapor barrier around the outlets, and pieces of urethane insulation were cut to size and glued to the outlet boxes. Mel said such care is essential to get the most energy efficiency from a superinsulated house. "You've got to take the time," he said.

Spending Money to Save Energy

Besides time, superinsulation takes extra money. On the basis of careful records, Mel calculated the cost of the added insulation, materials and related equipment that was necessary to bring the house up to superinsulation standards, compared to the usual HUD

standards (see Glossary). The extra costs were as follows.

22 rolls 3 1/2x24 fiberglass batts	$235.84
Additional 8 inches attic insulation	832.50
Additional 2 x 4 stud wall (100 studs)	163.00
Additional plates	47.00
Additional headers	60.00
High performance (low-E) windows (difference between double-pane and triple-pane)	285.00
46 sheets of high-R urethane	483.00
Heat recovery ventilator ducting	861.00
Heat recovery ventilator	1,310.00
Additional labor	1,000.00
Total Additional Cost	$5 277.34

These costs would be offset slightly by the savings from not having to purchase certain other materials and equipment. For example, if the single stud wall replaced by the double wall were assembled with 2 x 6 studs as HUD requires, rather than 2 x 4s, $122 would be deducted from the costs above. The two good quality bathroom fans and a good kitchen vent that would have been needed if no heat recovery ventilator was used would reduce the costs by another $350. These savings would bring the additional cost of superinsulation down to about $4 800, which is approximately 5 percent of the total $103 496.64 construction cost of the Campbell house. Mel said this 5 percent additional cost for superinsulation is about normal.

Construction costs could have been reduced by installing electric baseboard heaters rather than the Lennox pulse furnace. Mel said baseboard heaters for the house would have cost less than $1,000, compared to the approximate $5,000 cost of the pulse furnace and its required duct work. The difference between the cost of natural gas and electricity will at least slightly narrow the long-term cost between the two systems, Mel said.

Mel said the Campbells wanted the gas system because they thought it might be necessary to install air conditioning to keep the house cool during the blazing hot summer days on the Hi-Line, and the gas system with its duct work was compatible with central air conditioning. Construction costs include the cost of building the redwood deck and finishing the basement. With the basement, the Campbell house has a total of 3,840 square feet of living space, which cost about $27 per square foot to build. Mel said he could build a smaller (32 x 44) house on a similar pattern for about $60,000. Including the basement space, this would result in a cost of less than $22 per square foot for approximately 2,800 square feet.

The Campbells are perfectly satisfied with their house, but Mel said if he were to build it over he would separate the inner and outer stud walls with 6 inches of space rather than 4, to make room for still more insulation. Mel said he did not encounter any abnormal problems in building the house, though he did have to fire an electrician who refused to take the measures that were called for in the superinsulated design. "He wanted to put outlets everywhere on my outside walls, and overhead lights in hallways and closets."

Minor problems were encountered in obtaining materials. For example, the Tremco acoustical sealant needed for the air-vapor barrier was not available in Havre and Mel had to go to Great Falls to get it. Mel said he went to Havre and "did some talking at the lumberyard" and now Tremco is available there. □

Winter sun warms the living room of the Campbell house.

Going Underground in Eastern Montana

Owners
Bob and Phyllis Newton

Location
Glendive

Designer
Jim Rahr and Bob Newton

Builder
Jim Rahr and Bob Newton
Bloomfield Route
Glendive, MT 59330

Style
1 Story, Underground

Insulation
Roof - R10
Ceiling - R19
Rear and Side Walls - R15 top, R5 below
Front Wall - R11
Slab - None

Square Feet
2,500

Special Features
Extra Heavy Duty Underground Construction

Heat
Passive Solar, Wood

Completed
January 1980

When Bob and Phyllis Newton were thinking of building a house, they decided to go underground. Not merely earth-sheltered or earth-bermed, but underground, down there with the moles. When they started building back in 1979, the Newtons said their friends "thought we were nuts." There was a lot of talk about old-timers who had gone crazy living in dugouts. Now that the Newtons have been living in their comfortable house for years, however, many of the scoffers are envious.

The Newton house is located off the road outside Glendive, and a stranger to the territory needs good instructions to to find it. A country road winds through the low hills characteristic of eastern Montana, and the visitor comes around a corner and unexpectedly finds the house embedded in the landscape. The sudden appearance of the house is a surprise because there is nothing to indicate that a house is in the vicinity. Incoming utility lines are underground, and the house does not protrude above ground surface when viewed from the rear or sides.

Rugged Crafting Sets a Tone

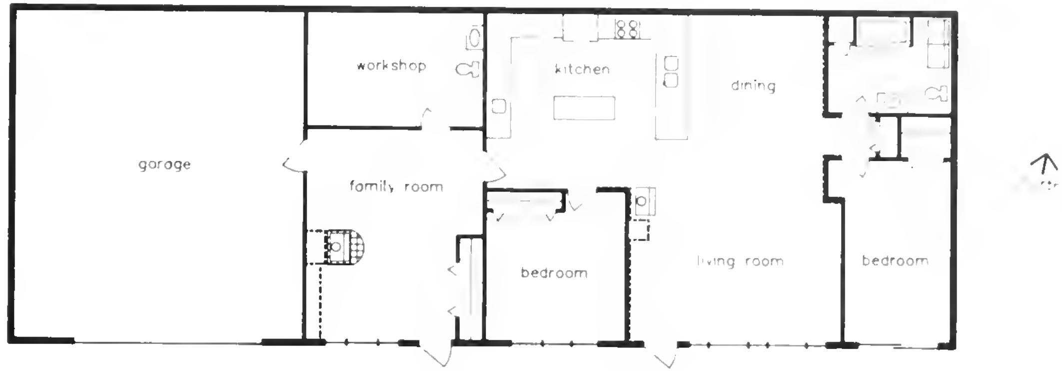
Students of architecture might refer to the Newton house as an example of the "Montana vernacular," meaning it looks native to its location. From outside, the front of the house is dominated by massive, reclaimed bridge beams

The Newtons' house fits nicely into the Montana scene.

Except for vent pipes and chimneys, the Newton house is invisible from the back side.

which are purely ornamental but give a feeling of log-cabin ruggedness. These beams form an apex over the entrance, and under this apex is a set of bleached elk antlers to complete the pioneer Montana motif.

The "rough-out" theme is continued in the rugged stone facing on the concrete retaining walls and outside of the front wall. All the stone used in the building was gathered within a mile or two of the building site. The outside stonework is matched inside the house by even more massive stone masonry that is pleasant to the eye and useful in maintaining uniform temperatures in the living space. The "roof" of the house has the appearance of average quality bunchgrass rangeland, with here and there a vent pipe coming out. The sloping roof overhang is shingled with thick cedar shakes that nicely match the external texture of the building and surrounding landscape.



A Do-it-yourself Project

Construction of the Newton house was an ambitious "do it yourself" project. In developing the design, the Newtons relied heavily on Phyllis' cousin, Jim Rahr, a retired builder. The only plan was one that Jim and Bob drew on the bottom of a Copenhagen box one day when they were sitting in a pickup talking about the project. This plan was accidentally thrown away when the box was empty.

Jim and Bob knew the house was going to need plenty of structural strength to support several feet of dirt, so they used concrete, and lots of it, in the walls and roof.

The first step in the construction was to dig a hole big enough to accommodate the planned 90 x 32 structure (including the attached double garage) in the south-facing hillside. Footings were put in, and the outside and interior divider walls formed and poured. The key element of the structural plan was the concrete ridgepole, which was to be 20 x 20 inches square in cross section and 90 feet long, poured in place as a single piece. A concrete form for the ridgepole was supported at the ends by the outside walls and in between by the divider walls and two 20 x 20 concrete pillars that were formed and poured in place. A dense mesh of reinforcing steel was used in the ridgepole. Six 90 foot lengths of 1-inch diameter reinforcing steel run the full length of the ridgepole, with shorter pieces of smaller diameter steel bar used to increase the strength. The network of reinforcing steel was so dense that one of the builders had difficulty retrieving his hammer after accidentally dropping it among the rods.

230 Yards of Concrete

Before they set about building the massive ridgepole, Jim and Bob investigated other options, such as the use of a prestressed concrete beam built off-site and then hauled in, or the use of a steel I-beam, but the cost of these options was far above the cost of pouring the concrete beam in place themselves. The Newtons said that if they were building again, they would pour the floor slab before they built the roof, to provide a better surface for bracing the roof forms.

After the ridgepole was poured and forms removed, forms were built for the rest of the concrete roof structure. This structure consists mainly of a concrete slab slanting up 16 inches from the outside walls to an apex over the ridgepole. Under this slab, and poured as one piece with it, are concrete reinforcing "rafters" 8 inches wide by 10 inches deep. These "rafters" were placed 4 feet apart so that standard-width sheets of plywood could be used to build the form sections between them. Each rafter contains four number 4 reinforcing rods.

Starting from one end, the concrete for the roof was poured in three sections, with each piece extending the full 32 foot width of the house. Each joint between the sections was placed over an internal wall for support. For maximum strength, the thickness of the roof slab tapers from about 8 inches at the ridgepole to 6 inches at the outer walls. The roof slab is strengthened with a network of number 4 reinforcing rods formed into a 12-inch mesh. The outer walls, including the front wall, are 8-inch reinforced concrete. The front wall extends 5 feet above the edge of the concrete roof structure, to provide a retaining wall for the dirt on the roof. Iron rods tie this wall back to the roof peak to strenghten the wall against the settling force of the dirt. This dirt is about 5 feet deep immediately behind the retaining wall, and about 4 feet deep over the peak of the concrete roof structure. The shake-surfaced portion of the roof that provides an overhang to limit the summer sun from the front windows is built with a standard 2 x 4 wooden framework attached to the retaining wall.

All the concrete used in the roof and walls of this structure was mixed with 6 bags of Portland cement to the cubic yard of concrete, for extra strength. The concrete in the 5-inch floor slab was mixed with 5 bags cement to the cubic yard of concrete, because it didn't need as much strength as the walls and roof.

Bob Newton waits for lunch as a snow squall rages soundlessly outside. Note massive stonework next to the wood stove

The floor was poured on a layer of sand 3 to 6 inches thick. The total amount of concrete used in the house was about 230 cubic yards.

One of the difficulties in the construction was figuring out where the electrical outlets would go, because the owners weren't sure of the floor plan. They solved this by putting an outlet every 4 or 5 feet in the walls and then covering up the ones they didn't need

Insulating the Structure

Once the concrete structure was in place, the builders sealed the outside with standard foundation sealer. They then placed a layer of 2-inch extruded polystyrene on the roof and along the top 2 feet of the outside walls. On the roof, they applied a continuous sheet of 6-mil polyethylene membrane over the foam. Jim explained that the purpose of the foam on the roof was to prevent frost from penetrating down to the concrete roof structure and possibly causing moisture problems.

When the concrete was cured sufficiently, dirt was backfilled around the walls. Eight inches of soil were applied over the foam on the roof, and a 1-inch layer of commercial bentonite was placed over the dirt. The intended purpose of the bentonite was to prevent water from percolating down to the concrete. There is no way of knowing if this was necessary, but so far the roof has not leaked. After the bentonite was in place, additional soil was placed on the roof to make it level from the top of

the front retaining wall to the original ground surface behind the house.

Drying the Concrete

Canadian studies show that it can take several years for concrete to dry out completely, and this can cause moisture problems in houses such as the Newtons' that use large amounts of concrete. However, getting concrete to dry is no problem during a hot dry eastern Montana summer, and the summer of 1979 when the Newtons were pouring their concrete was about as hot and dry as they get in the Glendive vicinity. The Newtons said their concrete seemed to dry out completely that summer.

Nothing Bizarre Inside

Inside, the house has a standard suspended ceiling. The 18-inch space above the ceiling provides room for plumbing and wiring, and is insulated with 6-inch fiberglass batts. The space above the insulation is vented at both ends of the building by 12-inch pipes that penetrate the roof and prevent moisture build-up. The inner side of the rear and side concrete walls was insulated with 1 inch of extruded polystyrene foam board. The foam was glued to the concrete wall surfaces with Number 11 Styrofoam glue. The same type of glue was used to glue the drywall to the foam board.

A standard 2 x 4 stud wall was built against the inner side of the front wall, and the spaces between studs were insulated with 3 1/2-inch fiberglass batts. All windows in the house are double pane.

Home Owner Contentment

The Newtons have been living in the house since January, 1980, and they are extremely pleased with it. The house is easy to keep warm with the large, blower-equipped wood-burning La Stove that produces whatever heat the sun doesn't provide. Once the massive stonework in the house is warm, it keeps the living space heated for hours with no need to keep the stove burning. A pipe was installed to provide the stove with combustion air from outside, which prevents the loss of heated inside air through the stove. The Newtons normally burn about 4 cords of wood per year.

The Newtons have left the house for several days at a time in cold winter weather and returned to find the inside temperature had dropped only a few degrees. When inside temperatures do get down a few degrees, however, it takes some time to restore the heat lost from the rocks. The house is equipped with electric baseboard heaters, but these rarely come on. The garage has an electric heater that gets used occasionally, but for the most part the garage is unheated. The 16-foot garage door is uninsulated, but water in an open sump a few feet inside the door has never frozen, even when outside temperatures were 30 below or colder and no heat was on in the garage.

At least one of the Newtons is usually home, so inside temperatures are kept at the comfortable level. September tends to be the warmest month in the house, because the sun is low enough to provide solar heating while the outside temperatures are still fairly high. The Newtons said 76 degrees was about the hottest the house has ever been, with 73 the normal maximum. One of the unexpected features of the house is the way heat tends to be uniformly distributed throughout the living space, with the farthest corner of the house being about as warm as areas near the centrally-located stove.

Plenty of Windows

All rooms except the bathroom have windows to the outside, and the interior is well-lit with natural light. The living space is comfortable and airy, with no "subterranean" feeling. The view from inside the house gives no indication that it is underground. The inside walls stay warm to the touch in winter, and the total lack of inside drafts helps make the house feel more comfortable than conventional houses. The thick soil cover deadens sounds from the outside, and even the eastern Montana blizzards are silent when viewed from inside the Newtons' house.

Labor Costs Not Known

The Newtons cannot estimate how much it would cost to have a contractor build a similar home, but they calculate it cost them about $65,000 to build their house themselves, including well and septic. □

A Warm Perch on the Edge of Town

Owners
Barry and JoAnn Nobel

Location
Great Falls

Designer
Owners and Corbett-Hanson, Architects
P O. Box 3706
Butte, MT 59702
494-2592

Builder
Owners and Subcontractors

Style
2 Story With Loft and Basement

Insulation
Loft Ceiling - R50
Vaulted Ceiling - R49
Double Walls - R38
Basement Wall - R19
Slab Perimeter - R10

Square Feet
Loft - 616
Main - 1,384
Basement - 1,384

Special Features
Superinsulation
Sun Porch
Vaulted Ceiling
Pulse Furnace

Heat
Passive Solar, Natural Gas Pulse Furnace

Completed
November 1985

Barry and JoAnn Nobel's new house in Great Falls has much that most Montanans would value. From its elevated hillside location on the north edge of town, the house provides a sweeping view of Charlie Russell country. At night, the city lights of Great Falls provide a friendly twinkle, and in the daytime, snow-capped mountains and hazy, distant plains rise in the background.

Not content merely to look at their surroundings, the Nobels wanted to adapt their living to the location. They built their house to be comfortable and economical to heat, even in the most invigorating Montana winter weather. Toward these ends, the Nobels chose a design with superinsulated double walls, thick attic insulation, a sun porch, heat recovery ventilator, and triple-pane windows. The extensive glazing on the south side provides pleasant natural lighting and warmth, along with a good view of the landscape. A sliding glass door leads from the main living space into the sun porch, where a hot tub provides year-round enjoyment.

The Nobel house has a commanding view from its hillside location on the north side of Great Falls.

Double Stud Walls

The outer walls in the Nobel house are double 2 x 4 stud walls, except on the south side which has a single 2 x 6 stud wall. The two stud walls in the double wall are 4 inches apart. The outer of these two stud walls bears the structural weight, and is assembled with the studs on 16-inch centers. The inner wall has the studs on 24-inch centers. The double walls are filled with two layers of R19 fiberglass batts. The inner batt is foil-faced and the outer batt is unfaced. The 2 x 6 studs in the south exterior wall are 24 inches on centers, with foil-faced R19 fiberglass batts between studs.

A Vaulted Ceiling

The vaulted ceiling is insulated with a layer of 9 1/4-inch R30 fiberglass batts and a layer of 5 1/2-inch R19 batts. The ceiling above the loft was insulated with 18 inches of loose fill cellulose having an R-value of at least 50. A continuous 6-mil polyethylene air-vapor barrier was applied under the drywall. All windows are Andersen triple pane. A VanEE heat recovery ventilator maintains air quality in the house.

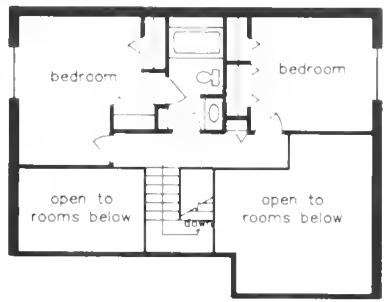
The Nobel house has 1,384 square feet of floor space on the main floor, another 1,384 in the unfinished basement, and 616 in the loft. A 40,000 Btu Lennox natural gas pulse furnace helps the incoming solar energy keep the upper two floors of this space heated to 70 degrees all day. Intake air and exhaust gases from the furnace pass through separate PVC pipes that penetrate the rim joist about a foot apart.

The Nobels reduce the thermostat setting to 65 degrees at night. The Montana Power Company at first estimated a "budget billing" rate of $29 per

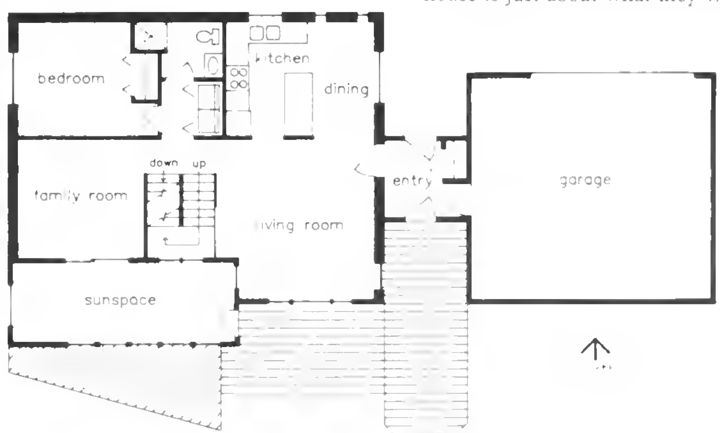
month for the Nobels natural gas bills, but this proved too high and the Nobels accumulated an increasing credit balance with the company MPC then changed the Nobels budget billing to $19 a month, which is plenty to cover their average monthly bill These bills include gas used by the State brand hot water heater This is a "sealed combustion" heater, with combustion air and exhaust entering and exiting through a common double-walled "pipe within a pipe."

The vaulted ceiling expands the spacious feeling of the Nobel living room.

UPPER LEVEL



MAIN LEVEL



Solar Helps Keep Bills Low

The passive solar design of the house helps keep heating bills low JoAnne said that on the day they moved into the house the temperature in the sun porch was 80 degrees, contrasted to the 22 below reading outside.

Low Construction Costs

The Nobels kept construction costs low by doing much of the work themselves. They hired out the framing, drywall, and carpeting, but did all else themselves. Total cost came to $75,000. This brings the cost per square foot for the two upper floors to $37.50 per square foot. This could be reduced dramatically by finishing the basement for use as living space, at a relatively small additional cost.

JoAnne said they are quite happy with their house, particularly with its energy efficiency and quietness. She said noise from outside does not penetrate the living space, "Even in a really bad windstorm." If they were building their house today JoAnne said, they might do a few things differently. For example, they would put in skylights. Other than that, she said, the house is just about what they wanted ☐

Living Beyond the Grid

Owners
Brandborg, Gussa, and Thorne

Location
Hamilton area

Designer
Dan Brandborg

Builder
Dan Brandborg
Sunelco
920 Highway 93 South
Hamilton, MT 59840
363-6924

Special Features
Photovoltaic Power
Instant Water Heater
Water Saver Toilet
Gas Refrigerator

Heat
Wood, Propane, Passive Solar

West of Darby 5 miles into the Bitterroot Mountains and 3 miles from the nearest utility pole, Dan and Becky Brandborg's log house reposes on 60 acres surrounded by U.S. Forest Service land. Mountain goats and bald eagles are their nearest neighbors. A few drainages away, and a mile west of the power grid, construction progresses on John Thorne's house on Fred Burr Creek. And across the valley atop a ridge in the Sapphire Range, Art and Betty Gussa live comfortably without a power line.

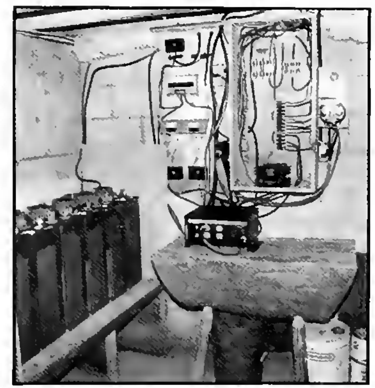
These home owners have a common bond—they all tap the sun for most of their electrical needs. Their power source not only frees them to live beyond the utility grid, it makes them some of the best energy managers around. By using alternate fuel sources and making every watt count, these modern Montana pioneers retain the conveniences of modern life in remote settings.

Racks of photovoltaic modules rest on the south side of Dan and Becky Brandborg's house. From dawn to dusk the modules turn sunlight into electricity to supply the Brandborg's power.

Squeezing Kilowatts

The secret to living with sun-generated electricity is to select appliances that either use fuel other than electricity, or that use miserly amounts of electricity. Dan Brandborg, who owns and operates Sunelco, a business that designs and installs photovoltaic systems, said a strategy for using less electricity means shifting large users of electricity, such as the refrigerator, water heater, cook stove, and space heater, to other fuels, and using energy-efficient appliances and lighting. "In the winter we use approximately 1.6 kilowatt-hours per day, in the summer 1.3. The Gussas use around 2 kilowatt-hours," Dan said. The impact of switching to other fuels is apparent, when you consider that the average American house consumes 25 kilowatt-hours per day, excluding heating.

To reduce the electrical load, wood is used for space heating and propane is used for other heating tasks and for cooling. The Brandborg's propane refrigerator uses just 1 pound of propane daily, or about 17 cents worth; an instantaneous water heater uses approximately 1 to 1 1/2 pounds of propane



A bank of heavy-duty batteries stores the excess kilowatts for the Brandborg house.

John Thorne is constructing his house several miles away from the power grid. A small photovoltaic array is supplying the power for his saws, sanders, and other building tools. More PV modules will be added as the electrical demand increases.

daily. The manually operated electronic igniter for the water heater pilot is accessible and easy to use, so the Brandborgs make a habit of turning it off when they're leaving or after dinner dishes are done. Their clothes dryer and range are also propane. Propane freezers are also available.

Where possible, direct current (DC) electricity should be chosen over alternating current (AC) for photovoltaic systems. "DC lighting and motors are generally more efficient," Dan said, "but most U.S. appliances run on AC. The disadvantage of low voltage DC is that it can't be carried long distances without high line loss."

The Brandborg's house has two sets of wiring—one for DC and one for AC. DC powers the Brandborg's lights, radio, and well pump. The washing machine, household appliances, and power tools are powered by AC.

"We suggest incandescent light bulbs for reading, and fluorescent or quartz halogen fixtures where larger areas need to be lighted," Dan said.

Conserving water minimizes pump use so the Brandborgs installed an Ifo toilet that uses just 1 gallon of water per flush. Faucet flow restrictors save even more water.

An All-AC House

Although the Brandborg and Thorne houses operate on both direct and alternating current, Dan installed an all-AC system in the Gussa's house. "It's not quite as efficient, but one wiring system is simpler and easier to use. The home owner doesn't have to remember whether an appliance plugs into an AC or DC outlet." The Gussas also have a microwave, dishwasher, and satellite television system.

An Ifo 1-gallon toilet conserves water, which means less energy needed to pump water from the well.

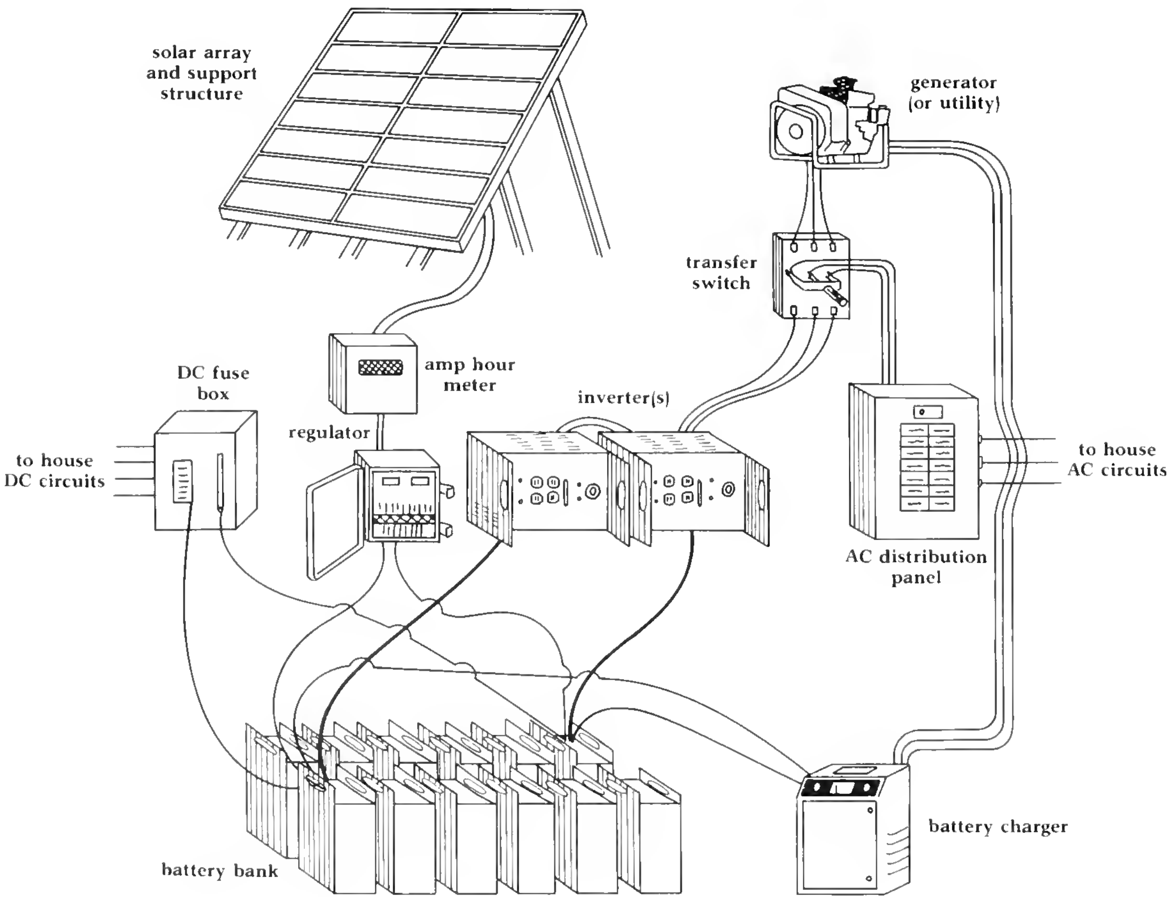
Turning Sunlight into Kilowatts

Racks of photovoltaic (PV) modules are the heart of the electrical generating system. Usually mounted on the roof, these cells convert sunlight directly into electricity. "In full sun, our 13-module PV array generates 500 watts," Dan said. The Gussas have a peak capacity of 650 watts, and the Thorne system generates 188 watts in full sun. For best exposure to the sun, the modules are oriented due south and tilted 65 degrees from horizontal during the winter and 30 degrees in summer. "The greater tilt in the winter also helps the arrays shed snow easily," Dan said.

"For PV panels to work well, they need a clear view of the sun between 10:00 a.m. and 2:00 p.m. Even the shade from a deciduous tree limb will interfere. Of course, the longer the sun shines on the panels, the more power they'll produce. But if Becky and I can make PV work at our house in the Bitterroot valley," he said, "it should work most anywhere in Montana. In this canyon, the south cliff cuts off the sun at 1:30 p.m. on December 21. We also have a lot of fog and bad weather."

PV panels are expected to last at least 30 years, although they could last 50 to 100. "There's nothing to wear out," Dan noted. "it's the environment that takes the toll." Tempered glass, like that in a windshield, reduces the likelihood of breakage, and hermetically sealed modules prevent the degrading effects of oxygen. "My panels are 5 years old and their performance is kind of like the Model-T compared to today's modules," Dan said. "But, like the Model-T, they probably will last for a good long time."

Hybrid DC/AC Photovoltaic System



Storing Kilowatts

The electrical current from the PV panels flows through a set of wires to where it's needed—lighting the house and running appliances and equipment, or into a bank of batteries to be stored. In the Brandborg basement, a 12-volt bank of 6 deep-cycle 2-volt batteries stores 1,200 ampere (amp) hours of electricity—approximately 13 to 14 kilowatt-hours (volts x amps = watts). "We have between 7 and 10 days of storage with no input of power whatsoever," Dan said. "The batteries will last 15 to 20 years. The secret to longevity in batteries is not discharging them too deeply. This means using large batteries and designing the system so a typical day of power usage will withdraw 10 to 30 percent of the stored power."

Art and Betty Gussa's 48-volt photovoltaic system stores 440 amp hours for a reserve of 21,000 kilowatts. The batteries are housed in a room which is insulated to R90. The Thornes' 12-volt bank of batteries has 1050 amp hours of storage. A built-in bench in the utility room harbors the battery bank in the Thorne house. Its central location reduces wiring runs and keeps the batteries warm. "Cold takes a toll on batteries," Dan noted. "Optimally, they should be kept around 60 to 70 degrees." All battery storage areas are vented to carry the potentially explosive hydrogen (generated when the batteries are charging) to the outside.

Controlling the Flow

An inverter transforms the 12-volt DC electricity to 115-volt alternating current to power AC appliances. The inverter can also include a battery charging circuit to receive AC power from a back-up generator and convert it to DC

to charge the batteries. "In earlier systems, the inverters' inefficiencies were a weak link," Dan said. "Today's units operate in the 90 percent range; that is, only 10 percent of the incoming power is lost in converting the current to AC."

A power controller or regulator monitors voltage. "When the batteries reach about 85 percent full charge," Dan explained, "the regulator turns most of the solar power off. Once the batteries reach 100 percent, the regulator turns off all of the incoming power. To prevent batteries from being too deeply discharged, the regulator has a sensor that disconnects the load from the batteries when a low voltage is reached. "Say if we go away for several days and leave the water pump on," Dan said, "the regulator would sense the drop in voltage and turn off the pump circuit."

Sophisticated controllers automatically respond to low battery voltage. When the battery charge drops to a certain point, the controller automatically starts a generator to recharge the batteries.

A Hybrid System

The Brandborgs' system is designed to derive 95 percent of its annual electricity from solar, and the remaining 5 percent from a backup gasoline generator. "Sizing the system so the full output of the PV modules is used by the load most of the year, and using the generator for those few times when the modules fall short of meeting the load is the most cost-effective method," Dan said.

The gasoline generator carries extreme loads or charges batteries during a long stretch of cloudy weather. "I call the system 'beauty and the beast,' Dan said. "On the one hand is the beauty—the quiet, non-polluting, renewable PV system. On the other is the beast—the noisy, smelly gasoline generator with

Planning a PV System

Home owners considering a PV system should tabulate their energy needs, similar to the sample shown in the table.

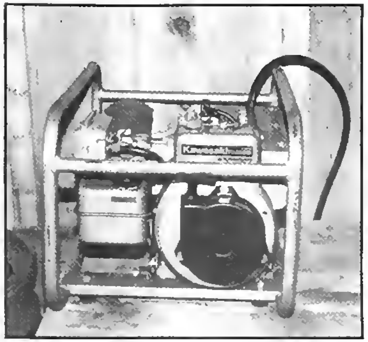
Sample Monthly Energy Budget

Qty	Daily Loads Load Description	Watts	AC/DC	January Hrs/Day	January Watts	July Hrs/Day	July Watts
1	Kitchen Counter Light Fluorescent	30	DC	4 0	120	3.0	90
1	Kitchen Table Light Quartz Halogen	35	DC	3 5	123	2.0	70
2	Area Lighting-Kitchen Fluorescent	20	DC	3 0	120	1.5	60
1	Living Room Light Quartz Halogen	35	DC	6.0	210	3 0	105
1	Bedroom Light Incandescent	50	DC	2 5	125	2 0	100
(Obviously, more than 6 lights will be in a home The power consumption of the additional lights is figured into the lighting loads above.)							
1	TV 13" color	40	AC	4 0	160	2 0	80
1	VCR VHS	30	AC	5.0	15	0.2	6
1	Stereo/Cassette Auto type	6	DC	3.0	18	3.0	18
1	Well Pump Pressure Type	120	DC	0 5	60	1.5	180
1	Washing Machine*	500	AC	0.2	100	0 2	100
1	Microwave	700	AC	0.1	70	0 1	70
1	Toaster 2 slice	900	AC	0.05	45	0 1	45
1	Vacuum	600	AC	0.05	30	0 05	30
1	Iron	1000	AC	0 01	10	0 01	10
1	Sewing Machine	70	AC	0.05	3.5	0 05	3.5
1	Hair Curler	16	AC	0.2	3.5	0.2	3.5
1-4	Carpentry tools	300-1,200	AC	0.05	25	0.1	50
	Total Daily Loads				1,238		1,021
	Battery inefficiency 15%						
	Inverter and wire loss 10%						
	Total unavoidable loss 25%						
	Multiply total wattage by 1 25 to compensate				1,548		1,276
	Solar Input. 500 watt-hours in full sun** (3 hours in January/ 5½ hours in July)				1,500		2,750
	Net Energy (solar input minus total loads)				(48)		1,474

*Three loads weekly at 30 minutes per load Although loads are usually run once or twice weekly, time is divided into daily fraction of hours

**The winter sun shines longer than 3 hours a day, but its intensity for whole day approximates 3 hours of full sun "Full sun" is based on the sun's line of flight and how close the earth is to the sun How much of the "full sun" can be captured in watt-hours depends on how many solar cells are perched on the roof

Source Sunelco



A small gasoline generator kicks on for heavy power loads or during long stretches of sunless days.

hundreds of moving parts. The generator does, however, produce enormous quantities of electrical power in a short time." The Brandborgs' generator uses about 25 gallons of gasoline each winter.

When A PV System Is A Bargain

Dan said photovoltaic systems are cost-effective for houses more than 1/2 to 3/4 of a mile away from a power grid. When the Brandborgs built their house five years ago, the power company quoted a price of $20,000 to extend a line from the utility grid 3 miles away. Today the powerline connection would cost even more while the cost of PV systems is dropping. "A residential state-of-the-art PV system costs between $7,000 and $12,000," Dan said. "Small systems for vacation homes or stock water pumping, of course, are considerably less."

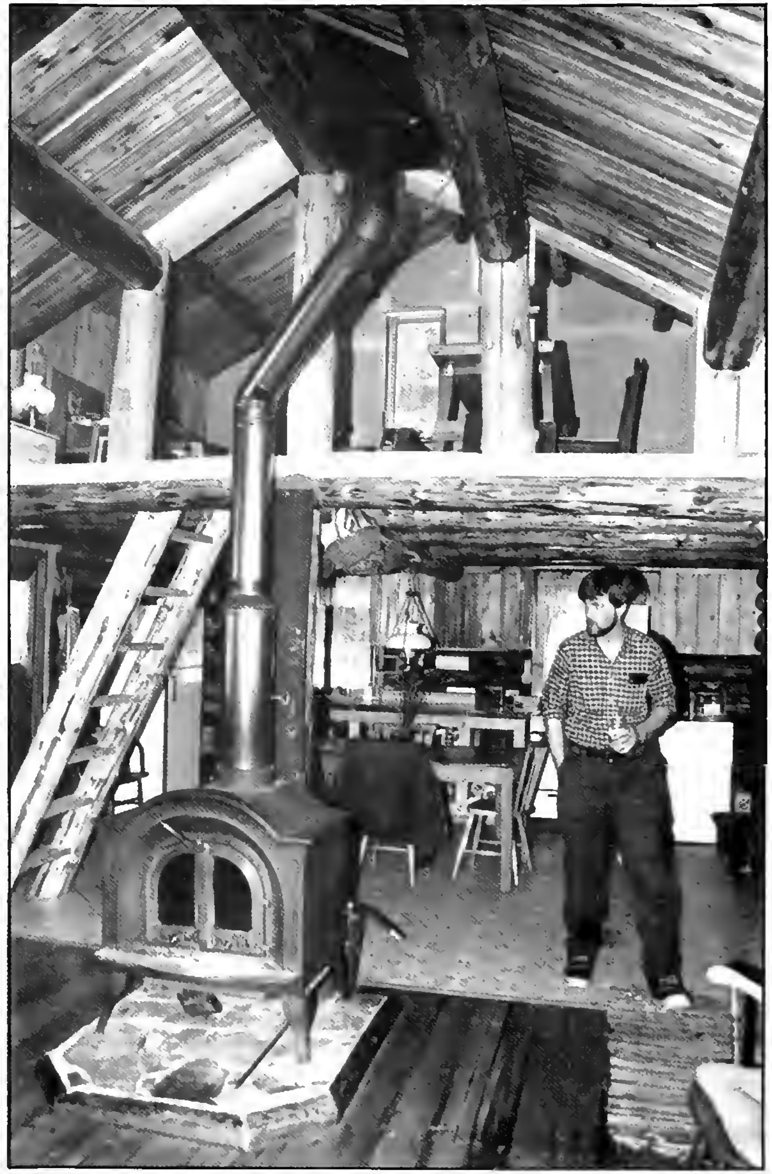
Dan suggested that home owners not wait until they build their house before installing a photovoltaic system. "Why constantly run a noisy generator to operate the saws, sanders, and other equipment needed to build a house when installing a PV system will let you work in peace and quiet," he said "Some people even start with a portion of the complete system. Batteries, with the inverter/battery charger unit, can limit the generator's use to less than an hour a day. Solar modules can be added as the budget allows, replacing the generator's role until it is only a backup unit."

That's what the Thornes did. They sized and purchased the batteries, regulator, and inverter for their total anticipated load, but installed just enough PV panels for the construction equipment. Their PV modules currently generate 188 peak watts per hour. They'll add more modules to bring their wattage up to meet the increased winter demands.

More than Cost Effectiveness

Prohibitive power line hookup charges are just one reason the Brandborgs, Thornes, and Gussas have photovoltaics over conventional electricity. "PV lets us be pretty much self sufficient," John Thorne said. "We don't have to worry about trees falling across power lines. And we like not getting a monthly bill from the utility company." ☐

Direct current powers the lights in the Brandborg house. A quartz halogen over the kitchen table provides plenty of illumination at a small cost in watts.

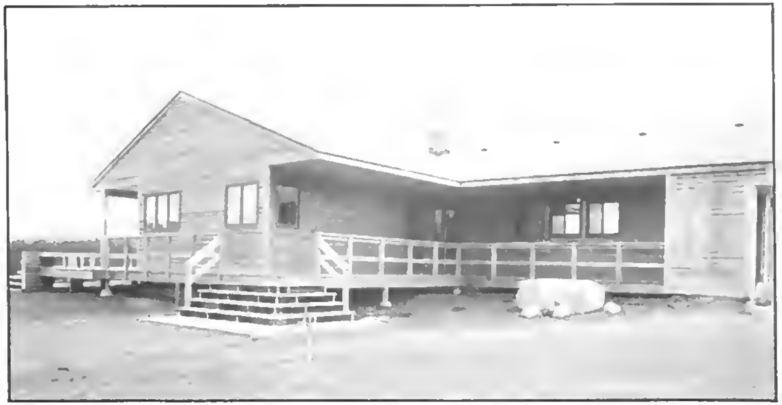


One-level Plan Saves Steps and Energy

Can heating with electricity in Montana cost less than heating with natural gas in southern California? Yes, according to Cliff and Bennielee Horton. "In San Diego our December heating bills averaged $250. We heated this house last December for considerably less than $200," Cliff said. "Our total electric bill for that month was $203. That was for everything, including Christmas lights. And I used my power tools in the shop a lot that month." A submeter which tracks electricity used for space heat was installed on January 7, 1987. From January 7, 1987, to October 4, 1987, the Hortons used a total of 5,022 kilowatt-hours (kWh) to heat their house. At a rate of .0485 per kWh, that amounts to $243 for the nine-month period.

Hamilton isn't Montana's coldest spot by a long way, but it's certainly colder than San Diego. So what paves the way to lower bills? "Design and construction," said Cliff. A look at the list of energy features in his house backs up his statement:

- North and east 2 x 6 walls filled with blown-in-blanket fiberglass insulation (BIBS) and sheathed with foil-faced polyisocyanurate rigid foam board on the exterior
- West double wall of 2 x 4 and 2 6 x 6 studs with BIBS
- South 2 x 6 wall with BIBS
- Roof insulated with blown-in fiberglass to R49
- 6-mil polyethylene air-vapor barrier in ceiling and walls, overlapped and caulked
- Crawl space insulated with fiberglass batts on walls and in floors, and a 6-mil polyethylene moisture barrier over the ground
- VanEE-2000 heat recovery ventilator Insulated Stanley and Therma-Tru exterior doors
- Clawson casement and awning windows with double-glazing and low-E film



A sheltered entry in the northeast corner of the Horton house protects visitors from snow and rain, and the expansive deck offers room for lounging on sunny days. The house is one of 31 in Montana that was built under the Residential Construction Demonstration Project.

Part of RCDP

The Hortons' home is one of 31 in Montana participating in the Residential Construction Demonstration Project (RCDP). When the Hortons' son, architect Dale Horton, drew up the house plans according to Cliff and Bennielee's specifications, he realized how close it was to the RCDP specifications and suggested they apply for the program.

As one method for checking the performance of houses in the program, the Montana Department of Natural Resources and Conservation (DNRC) conducts a blower-door test. The Hortons found the test particularly revealing. "The house is really tight," Cliff said. "The builder caulked everything—mudsills, windows, doors. But you just don't realize where air can get through a house. Would you believe we had air coming through the deadbolt lock—right around the pin?"

Owners
Clifford and Bennielee Horton

Location
Hamilton

Designer
Dale Horton, Architect
P O Box 7812
Missoula, MT 59807
549-8663

Builder
Martin Builders
2540 Highway 93 North
Victor MT 59875
642-3514

Style
1 Story

Insulation
Ceiling - R49
Double Wall (West) - R40
2 x 6 Wall (North and East) - R28
2 x 6 Wall (South) - R22
Crawl Space Walls - R17
Floor - R19

Square Feet
2,316

Special Features
RCDP Construction
Outside Combustion Air

Heat
Electric Forced Air

Completed
October 1986

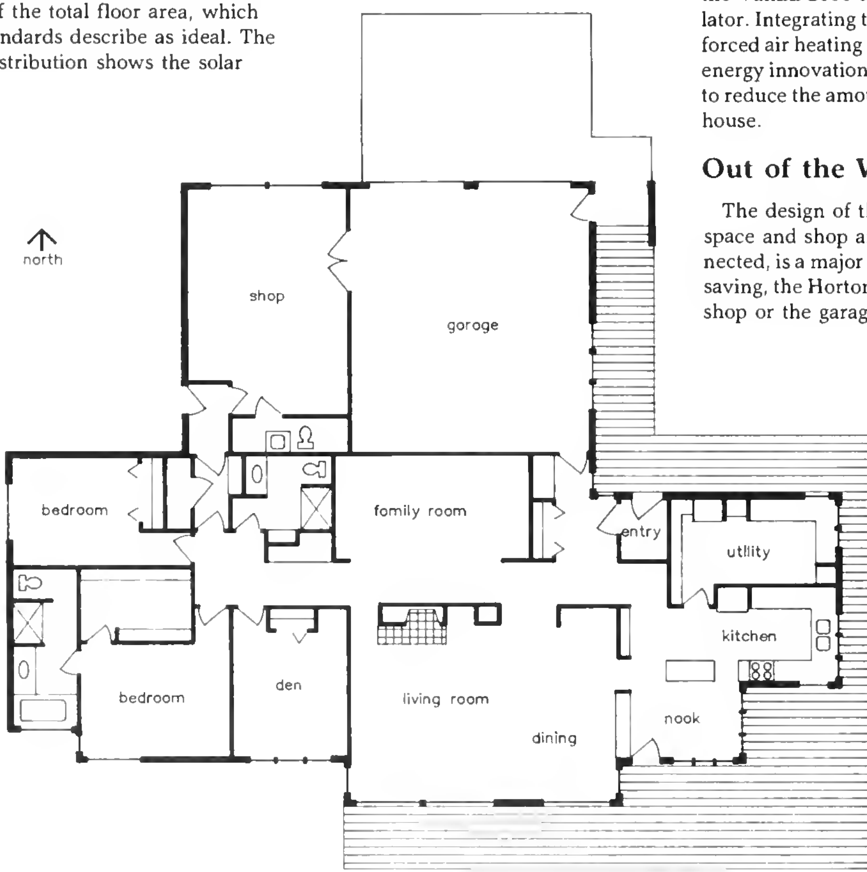
Windows Fit Floor Space

But energy savings come from more than insulation and an air-vapor barrier. "You have to design a house properly and face it in the right direction for solar gain," Cliff said, directing attention to the vaulted living area with its bank of south-facing windows and protective overhang. "We get a lot of heat from the winter sun." The 326 square feet of windows represent a little less than 15 percent of the total floor area, which RCDP standards describe as ideal. The glazing distribution shows the solar design, with 62 percent on the south, 25 percent east, 8 percent west, and 5 percent north.

Heat Integrated with Ventilation

Most of the time, the Hortons depend on their electric forced-air furnace. Rated at 15,000 kilowatts, it's about one-third the size of the output of the gas furnace they had in San Diego. "Our son, who designed the house, had to convince the heating contractor to put in such a small one," Cliff said. "But, it certainly does the job. Because of the tight construction, we don't have any cold or hot spots."

A single duct system delivers warmed air from the furnace and fresh air from the VanEE-2000 heat recovery ventilator. Integrating the ventilator with the forced air heating system was one of the energy innovations sponsored by RCDP to reduce the amount of ductwork in the house.



Out of the Weather

The design of the house, with living space and shop and garage all connected, is a major advantage for energy saving, the Hortons said. "I can go to my shop or the garage without going outside," Cliff said. Airlock entries at the front and back doors leading outside prevent cold air from rushing in.

Cliff's second home is the shop on the north side; it is not heated by the furnace. Even with its two north-facing windows, the shop temperature has never dropped below 45 degrees and the adjoining bathroom doesn't get below 54 degrees. Double doors connect the shop to the garage. Cliff can easily move large pieces of wood through the double doors. They also allow heat to flow into the garage from a wood stove in the shop. "When it's 30 degrees outside, I can fire up the stove in the shop and have the garage up to shirt-sleeve temperature in about an hour," Cliff said.

Custom Kitchen and Utility

Bennielee had the say on kitchen and utility room design. "I worked with James Vetter, the cabinet manufacturer here in Hamilton, to place every cabinet in the kitchen and utility room the way I wanted to use them," she said. In the kitchen three lazy Susans make use of corner cupboard space. Roll-out shelves bring pans and cans into easy reach. In the utility room, Bennielee pointed out the features for convenience: a recess in the wall for the ironing board, a rod for hanging clothes and tablecloths, and laundry bins that slide on rollers out of sight under a counter. To minimize visual clutter, electrical outlets have been placed as close to the floor as code allows.

Both Cliff and Bennielee said they couldn't think of a thing they'd change. With one heating season behind them, they are pleased with their home's performance and feel energy-efficient housing was the right choice. □

A handsome brown brick fireplace is the centerpiece for the Horton's living space. It separates the living room from the family room. The fireplace's mass soaks up the bountiful warmth pouring in from the low-lying winter sun, and slowly releases it during the cooler evening hours. When the Hortons use the fireplace, which isn't often, combustion air is drawn through a pipe from outside to the Heatform firebox.

Low Income Can Buy Energy-efficient House

Owner
Cynthia Taylor

Location
Hamilton

Designer
David Lilyquist
N.W 660 Park View Drive
Hamilton, MT 59840
363-2161

Builder
Campbell Massey
888 Coal Pit Road
Corvallis, MT 59828
961-3704

Style
1 Story

Insulation
Ceiling - R60
2 x 6 Strapped Wall - R25
Floors - R30
Crawl Space - R11

Square Feet
Main - 862

Special Features
RCDP Construction
Airtight Drywall

Heat
Electric Baseboard

Completed
August 1986

Caught between exorbitant heating bills and a lean income, Cynthia Taylor resolved to do something about the squeeze. Her efforts resulted in one of the first low-income, superinsulated houses in Montana.

Cindy got the idea for building an energy-efficient house while working at the Ravalli County Electric Cooperative. "I had funds approved from the Farmers Home Administration," Cindy said. "Rudy Kratofil, Conservation Supervisor at the Co-op, works with customers on weatherizing their houses and building energy-efficient houses, and he encouraged me to build an energy-efficient home. So the energy-saving features were designed into the house, and my builder submitted the house plans to the Residential Construction Demonstration Project."

Local Utility Can Help

"Anyone who is thinking about building a house should stop by their local utility and let them know they're in the market for a house," Rudy Kratofil said. "When Ravalli County Electric Cooperative holds a builder's workshop, we call all the people we know who are thinking about building. One individual went to a builder's seminar to meet and hire a builder. He said he didn't want anybody building his house who hadn't attended one of the workshops."

The workshops, sponsored by the electric cooperative and DNRC, show builders new energy-efficiency techniques. Attendance is required for those builders who want to take part in building

Cindy Taylor's house is proof that those with low incomes can own an energy-efficient house. The house affords comfortable and economical living quarters for those on a tight budget.

The house makes the best use of space, with little area wasted in hallways. South-facing windows in the living room and master bedroom bring in free heat from the sun.

programs sponsored by Bonneville Power Administration, such as RSDP, RCDP, and Super Good Cents.

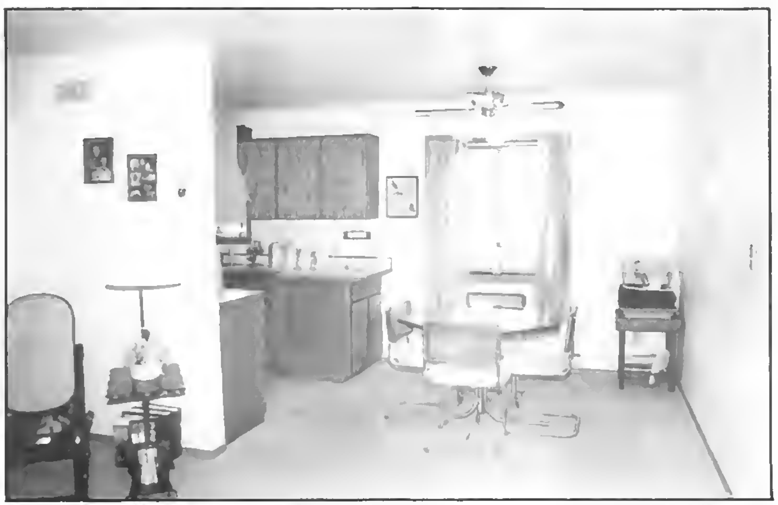
Cindy's builder, Campbell Massey, was one of the builders who had attended a workshop and was familiar with the RCDP. He helped qualify Cindy's house for RCDP funding. These funds paid for the energy-saving features, such as extra insulation, a heat recovery ventilator, and the extra cost for gasketing and vapor barrier paint for the drywall.

Built on A Budget

Simplicity and efficiency kept the cost of Cindy's house under her budget. The walls are constructed to get maximum R-value without the expense of double wall construction. By furring the 2 x 6 studs with 1 x 1s, extra space was built into the walls to accommodate 6 1/4 inches of Insulsafe-III blown-in-blanket insulation (BIBS). In the ceiling, raised heel trusses allow room for 12 inches of fiberglass insulation. Airtight drywall acts as the air-vapor barrier.

Total window area is about 10 percent of the house's square footage. All windows are double glazed with low-E film. To keep drafts out, the framing around the windows was insulated with polyurethane foam. Before foaming around the windows and framing, the builder braced the studs to counteract the pressure of the expanding foam, and left the braces in place for a week before he trimmed the foam.

Although just half the windows face south, plenty of free heat comes pouring in. "When the sun is out, even though it's only 20 degrees outside, I don't have to turn on my heat until seven or eight at night," Cindy said. "I rarely turn on the heat in my bedroom."



Although the kitchen and dining room have north-facing windows, the double-glazing and low-E film keeps heat loss to a minimum.

Ventilator Cleans Air

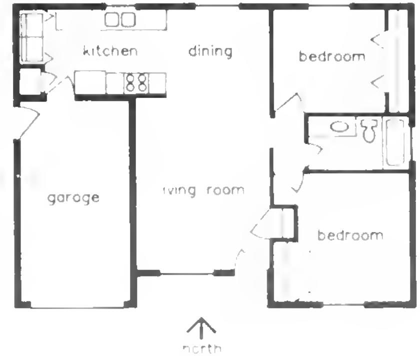
A Van-EE 2000 heat recovery ventilator runs continuously on low to bring fresh air into the house and remove odors. "I used to smoke a lot, and I found out how tight this house was when I shut off the ventilator one night," Cindy said. "The next morning the air in the living room, full of my stale cigarette smoke, looked like a fire was smoldering in there."

One minor problem with the ventilator occurred when Cindy first moved in. "Something built up in the filter and spread a light, fine dust on everything. After I took out the filter and cleaned it, the dust cleared up," she said. She has no trouble with condensation forming on the windows.

Construction Keeps Electric Bill Down

So far, the home's energy performance is better than Cindy hoped for. Between September 1, 1986, and June 1, 1987, her electricity use averaged 3,526 kilowatt-hours (kWh) for space heating, 1,830 kWh for water heating, and 3,294 kWh for other uses, such as lights and cooking. At 4 1/2 cents a kilowatt-hour, that adds up to $158 for heating and $82 for hot water during the heating season. "I'm really pleased," Cindy said. "I hadn't wanted electric heat. I like a warm house and the electric bill for the heat in my rented place had been terribly high. But Rudy encouraged me to try electric heat in a well-insulated house."

"Think about the low usage of Cindy's house," Rudy said. "There'll be enough energy saved to provide another house with power. These well designed and properly insulated houses are 50 to 60 percent more efficient than houses built to HUD standards."



Making Space Work

The streamlined two-bedroom house affords plenty of room for Cindy, her Doberman pinscher, a poodle, and one bird. The dining area and kitchen share space for ease of food preparation and serving. A convenient back door lets the garage double as an airlock entry, which keeps mud and dirt from being tracked through the living room. To leave more space in the utility room, an energy-efficient hot water heater was installed in the crawl space. Its location just below the big hot water users—washing machine and sink—shortens the waiting time for hot water at the faucet and reduces the amount of heat lost in pipes. The heater is insulated on the inside and has an insulating jacket on its exterior.

Single income and low-income families shouldn't give up on owning a house," Cindy said. "They can afford to build and maintain their houses through low-income funding and by designing their houses to meet Montana's Super Good Cents program. And why anyone low income or not, would want to build anything but an energy-efficient house is beyond me. The comfort and money saved are unbelievable." □

Solarcrete Walls Defy Elements

Owners
Gary and June Hartze

Location
Helena

Designer and Builder
Hartze Construction, Inc.
6154 Highway 12 West
Helena, MT 59601
443-3533

Style
Raised Ranch

Insulation
Ceiling - R60 blown-in cellulose
Walls - R37 expanded polystyrene

Square Feet
Main - 1,600
Basement - 1,500

Special Features
Solarcrete Construction

Heat
Electric Air-Air Heat Pump

Completed
1983

Partly hidden in the pines and sage on the rolling hills just west of Helena is a house that looks ordinary but isn't. Like many houses in Montana, its long side faces south to capture winter sunlight, and its lower level is partially embedded in the earth's buffering warmth. But under the warm, brown stucco exterior is a construction style that makes this house a miser in energy consumption.

The miserly aspect starts with the walls of the house—inner and outer shells of 2-inch reinforced concrete sandwiching 8 inches of expanded polystyrene insulation through a technique known as the "Solarcrete" Building System.

Superior insulating qualities (R37 in the walls) and no maintenance are just two of the reasons Gary and June Hartze used Solarcrete when they built their house in 1983. "Solarcrete walls have continuous insulation, so the heat doesn't have a direct path to the outside. The house also has above-standard ratings for resistance to earthquakes and fire," Gary said.

Gary Hartze, a building contractor in Montana for 15 years, said that the Solarcrete method has been used widely in the Midwest and Southeast, and is just now making its way to Montana. He's the authorized Solarcrete builder in Montana east of the Rockies. In addition to the Hartze's house, Helena's Tire-Rama store also was built with Solarcrete.

Timbered hills and a large garage buffer the Hartze house from cold north winds. Most windows face south, gathering considerable heat from the winter sun. No windows face north. The exterior Solarcrete walls of the house are finished with maintenance-free, pre-colored stucco and trimmed with oiled tongue-and-groove cedar trim. The deck across the east and south side is also cedar.

Special Wall Treatment

Frames for the Solarcrete walls were assembled on the ground. First, a rigid framework was constructed from steel rebar connected with heavy-duty web ties and bar clips. Then 8 inches of expanded polystyrene insulation was inserted into the framework. Wire mesh was stretched over the framework to reinforce the structure and serve as an attachment for the concrete.

The wall frames were tipped into place by hand and secured to the footings. Gary said even the biggest section, 26 feet long and 18 feet high, required only four men to tip it into place. Once the wall frames were in place, workmen used a large hose to spray a 2-inch-thick layer of high-stress concrete on each side of the wall panels. This concrete adheres to the wall frame without slumping or sagging.

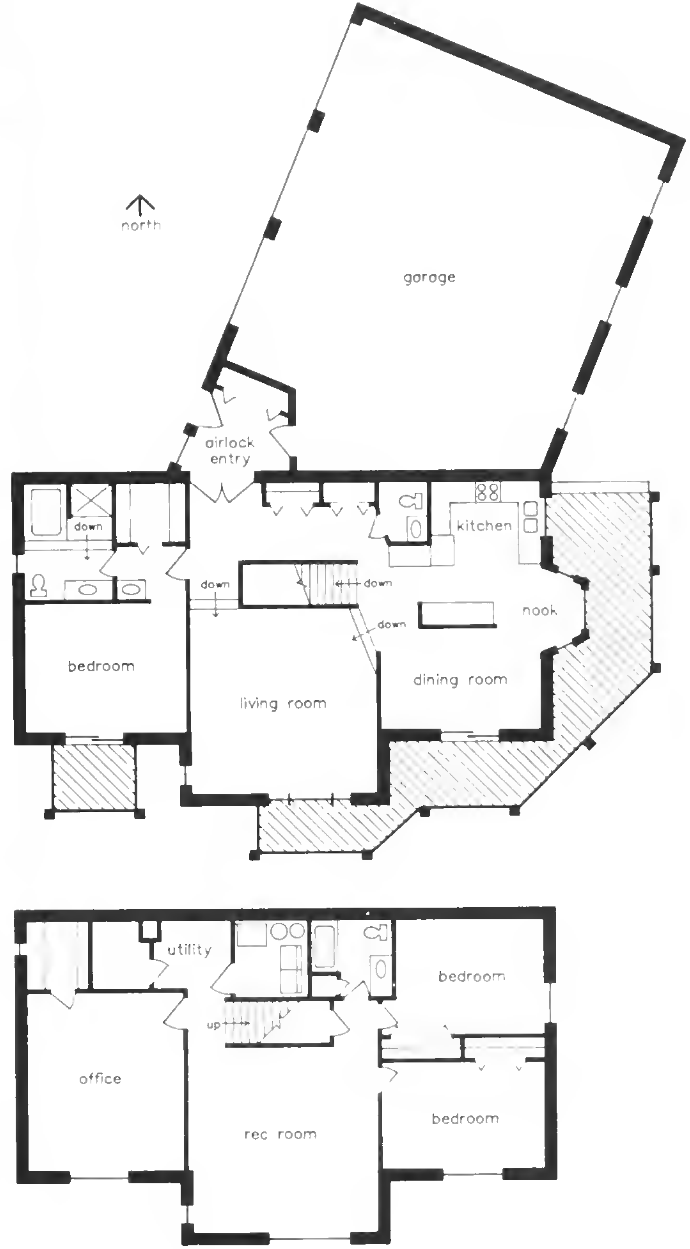
House Requires Little Heating or Cooling

"This house is tight," Gary said. "Often our internal heat sources—us, the appliances, and so forth—give us enough heat. When we have 8 to 10 people in here, their body heat will keep the place warm, even at zero degrees."

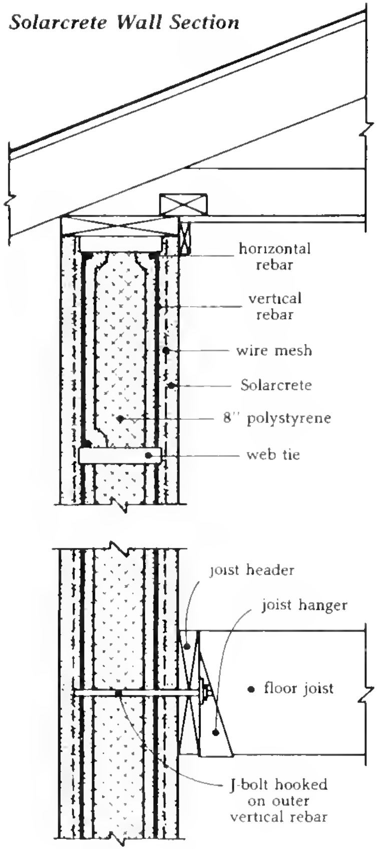
The Hartzes use a Coleman air-to-air heat pump to heat the 3,100 square feet of their house. The heat pump also serves as an air conditioner. "On 100-degree summer days, I can cool the house for less than a dollar a day," Gary said. The pump costs about $150 a year to operate. "My heat pump is metered separately, and I have good records of heating bills," Gary said.

Solarcrete walls can be finished in a variety of ways. In their living room, Gary and June Hartze glued tongue-and-groove cedar paneling on one wall, and textured and painted another. Wallpaper covers hallway and bathroom walls. Underneath the wall coverings, the concrete wall absorbs the warmth from the low winter sun, then releases that warmth as the rooms cool in the evening.

In the downstairs recreation room, country-patterned wallpaper above cedar wainscoting provides a cheery setting for a pool table. Garden-level windows on the south admit plentiful sunshine.



Solarcrete Wall Section



Controlling the Ventilation

A VanEE-200 heat recovery ventilator freshens the air inside the house. Exhaust air from the house, the dryer, and Jenn-Air range is vented out the east side of the house. Fresh air is ducted in from the west side.

Gary has some advice on heat recovery ventilators. "I tell people to clean the filters, then leave the ventilator alone. It doesn't take much fiddling to get a ventilator out of balance. People twist knobs and they don't know what they're doing. The ventilator should be controlled by the dehumidistat in the living area or by the manual timers in the kitchen and bathrooms. The dehumidistat should be set according to the outside temperature and humidity."

Cost Varies With Price of Concrete

As far as cost for a comparable home, Gary said there is no "average" cost per square foot for a Solarcrete house because the price of concrete varies from town to town. The price also depends on whether the house is located in town or the country. Gary has a 15-minute movie about Solarcrete construction and is willing to show his house to anyone interested in this method ☐

An insulated steel front door opens to an airlock entry from which French doors provide an inviting view into the home.

Wood Underpinnings Support Energy-saving House

Although wood foundations have been in use for several years now, they are still something of a novelty. However, Judy and Hal Hay decided a wood foundation would be just the ticket. "I had absolutely no qualms about installing this type of foundation," Hal said. "Our site is on porous rock and we have no drainage problems whatsoever. I wouldn't install one on clay soil, though. Drainage and frost heave could put substantial pressure on the foundation."

Hal is manager of Intermountain Lumber in Helena and is familiar with wood foundations and their benefits. A dry, warm basement that would make a comfortable living space was the impetus for selecting the wood foundation. "I think it's easier to insulate a wood foundation, and to run pipes and wires through a 2 x 6 stud wall than it is concrete," Hal said.

Sequestered in the pines south of Helena, Judy and Hal Hay's house balances energy-efficient construction with economical gas heat and some passive solar gain. A wood foundation supports the three-story house. The west overhang protects a bank of windows from the hot afternoon summer sun.

No Room for Mistakes

Hal cautioned that going by the book is important. "The wood used for the foundation has to be specially treated. The nails have to be corrosion-resistant. The plywood seams have to be sealed with moisture-proof caulk. "You don't cut corners when you put in a wood foundation, especially when it's holding up three stories," he said.

The Hays started with a leveled site over which 6-mil polyethylene was placed as a moisture barrier. A continuous 8- x 16-inch concrete footing was poured around the perimeter of the house, and a 4-inch concrete slab was poured over gravel. Treated 2 x 10 fir studs, installed on a wide mudsill anchored to the footings, frame the foundation walls. Blown cellulose fills the stud cavities of the foundation for an R-value of 30. Treated 5/8-inch plywood sheathes the exterior. After caulking the exterior plywood seams, the plywood was painted with two coats of a fibred-asphalt foundation coating. A 6-mil polyethylene moisture barrier was applied as the final exterior layer before backfilling.

The basement was backfilled to the second floor on the entire east side, and the east half of the north and south. Double swinging patio doors on the south side and a bank of west windows bring sunlight into the downstairs bedrooms. An insulated steel door on the north provides access to the outside.

Owners
Hal and Judy Hay

Location
Helena

Designer
Mike Stevenson, Architect
Stevenson Design and Associates
Birney MT 59012
984-6281

Builder
Jim Bentley
910 Park Drive
Helena MT 59601
449-7194

Style
2 Story with Basement

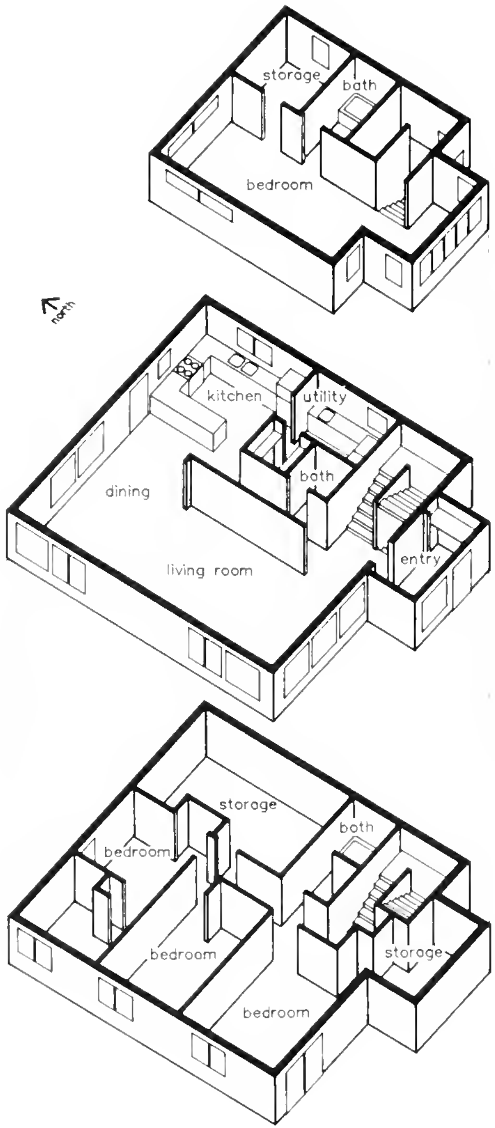
Insulation
Ceiling - R60
2 x 6 Walls - R30
Basement Wall - R30

Square Feet
Upper - 556
Main - 1,096
Basement - 1,096

Special Features
Wood Foundation
Airlock Entry
Outside Combustion Air

Heat
Natural Gas Hydronic

Completed
December 1985



Foam Board Sheathes Interior Walls

On the upper two floors, a combination of heavy insulation with good ventilation prevents condensation problems and keeps the house warm. The 2 x 6 walls are filled with blown cellulose and sheathed with 1-inch tongue-and-groove extruded polystyrene on the inside. To cut down air infiltration, Tyvek was applied over the exterior oriented strand board (OSB).

Instead of a whole-house heat recovery ventilator, fans in the bathroom and over the electric range ventilate those areas that produce most of the moisture and odors in the house.

Free Heat with a View

Although the house is surrounded by tall pine trees and neighboring houses, careful design and placement opened it up to the sun and a view. A 6 x 12 extension on the south side affords room for an airlock entry on the main level and

An insulated glass exterior door and adjacent window (concealed by wall on the right) and double glass interior doors admit plenty of southern sun to the living area. Rust-colored quarry tile provides storage for the sun's warmth.

a small sunspace on the top floor. Sunlight streams through an insulated glass entry door and window and into the main living area through double glass doors. Quarry tile absorbs some of the solar heat. Windows along the south, west, and north sides of the large living space afford a view to the garden, timbered hills, and Helena valley. Adjacent to the master bedroom, a small sunspace collects free heat for the upstairs. Windows are all double glazed with low-E coating.

Verosol medium-weight shades temper the flux of heat and cold through the windows. Judy had her doubts about the efficiency of the shades. But when she opens them in the morning after a cold night, she says she can feel the rush of cold. In the summer, of course, they work very well to turn away the sun's heat.

Economical Gas Hydronic Heat

The Hays chose gas-fired hot water for an even, quiet heat. A 90 percent-efficient Amtrol natural gas boiler heats the water which is piped to the baseboard heaters. To provide the combustion air needed by the gas boiler, outside air is ducted through the side of the house to the mechanical room in the basement. The plastic ducting bringing in the air ends in a bucket where the heavier cold air pools in the bottom. "The air in the bucket stays around 30 degrees in the winter while the rest of the room is around 68 degrees," Hal said.

The daytime temperature is kept at 68 for the comfort of Judy and their three young children who are at home during the day. The thermostat is set back to 60 at night.

The gas heat is economical as well as comfortable. "Before we built the house, we ran the building specifications through a computer program to project the heating bill," Hal said. "We're doing much better than what we anticipated. Our monthly utility bill averages $46.00. This includes all gas and electricity." ☐

The Hay's large open living space promotes circulation of air warmed by hydronic baseboard heaters or south-facing windows. Creamy white walls and light carpeting diffuse light and enhance the rich grains of the wood beams and tongue-and-groove fir ceiling.

A Warm Place With A View

Owners
Greg Jahn and Christine Torgrimson

Location
Helena

Designer
Owners and Various Consultants

Builder
Owners and Larry Jahn

Style
2 Story

Insulation
Ceiling - R60
Double Wall - R40
Slab - R7

Square Feet
Upper - 784
Studio - 528
Main - 1,524

Special Features
Attached Greenhouse
Direct Vent Gas Appliances

Heat
Natural Gas

Completed
June 1985

A bay window that grew until it became a bow wall with five windows reveals the desire of Greg Jahn and Christine Torgrimson to fully enjoy their view of Helena and to have a house filled with natural light. "We're both Montana natives and we want to stay here," Greg said. "But to keep from migrating south in winter, we have to have sufficient daylight. And, we have to be warm. After living in an extremely drafty farmhouse, neither of us ever wanted to be cold again."

Triple-glazed windows minimize heat loss while providing plenty of light and a commanding view of the Helena valley.

Class Plants Idea

A college community class in Bozeman convinced Greg and Christine to build an earth-sheltered, superinsulated house with maximum glass on the south side. They also wanted a greenhouse. To get started, Greg and Christine each designed the house of their dreams, then put their two plans together. Over the next year they often consulted with Russ Heliker, builder, and his wife, Linda Brock, an architect. (See related article on page 25.) After building a cardboard model, they embarked upon construction.

Double 2 x 4 walls frame the second level and three sides of the first level. The fourth wall at the rear of the first level is concrete, set below ground level. This wall is insulated with 1-inch extruded polystyrene on the outside and a 2 x 6 insulated wall on its interior. Above the ceiling, raised heel trusses provide plenty of room for insulation. Rows of soffit vents and a continuous ridge vent promote air circulation in the attic. Tyvek beneath the redwood siding tightens the house against air infiltration.

A heat recovery ventilator brings in fresh air and exhausts stale air from the house. "We turn it on when the house is stuffy, when we burn something, or when we leave," Christine said. "It really does the job, but because the house is so quiet, the noise of the ventilator's fan is quite noticeable to us."

Just two plumbing vents penetrate the ceiling vapor barrier. A State gas hot water heater brings combustion air in and vents out through the side wall, as does a natural gas space heater in the living room. Greg's pottery studio, above the garage, has its own vapor barrier separate from that of the main house to keep moisture from migrating out of the more humid studio into the living space. The studio also has its own electric hot water baseboard heating system and a dehumidifier.

Artistic Touch on Finishing

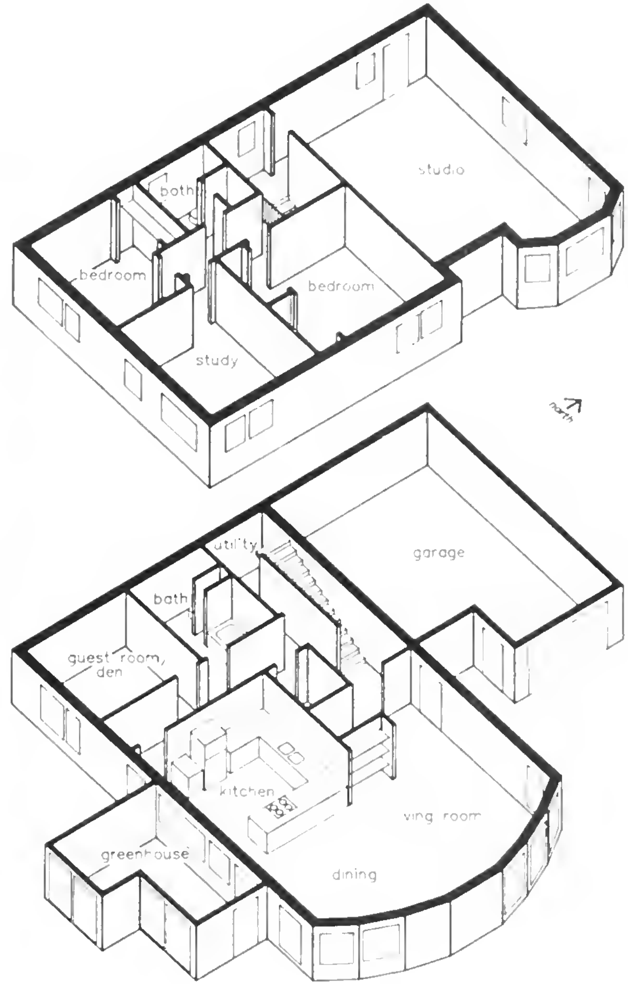
The interior finishing exemplifies Greg and Christine's artistic capabilities. Cream-colored walls and oatmeal-toned carpeting in the living room complement the dining room's polished hardwood floor and the tongue-and-groove fir and larch covering the vaulted ceiling. Thick rust-hued tiles handcrafted by Greg pave

the entryway. The double-wall construction that keeps heat in also provides deep sills for the triple-glazed windows—opportune display space for Greg's pottery and a mix of plants, as well as a favored resting spot for two friendly cats. Tongue-and-groove fir and larch accents one wall of the guest bedroom. Cherrywood cabinets enhanced with a pottery basin highlight the main bathroom.

Small Space Heater Warms Tight House

The house performs as Greg and Christine anticipated. "We leave the temperature at 70 degrees and our gas bills

A natural gas heater occupies a small area of the living room (located between the lamp stand and the window on the left). Combustion air is channeled directly to the heater through an outside vent.



total less than $200 a year," Christine said. A Perfection direct vent natural gas heater rated at 20,000 Btu keeps the entire house toasty warm. This heater is small, only 2 feet x 3 feet x 1 foot, and is installed on the north wall of the living room. The open floor plan and wall vents to the upstairs rooms promote air circulation. "Heat diffuses thoroughly when it isn't being lost through walls and windows," Greg said.

Cold No More

Asked if they would do anything different, Greg said they might think twice before again taking on the monumental task of building a house themselves. "We had a dream to design and build and understand our house. We spent months researching and a year building and we have all this knowledge. I'm not sure we'll really use this knowledge again, but we're truly satisfied with the home we've created. And, we aren't cold any more." □

Rock from the Blackfoot River and the Helena valley forms a wall joining the kitchen and greenhouse. The rock provides heat storage, soaking up warmth and releasing it when indoor temperatures cool.

Buffeted by Winds

Near an aspen grove on a slope in Tucker Gulch outside Helena sits the house of Dan and Cheryl McCauley. The site would be less than ideal for a house built with conventional construction. The house is on an open slope, and there is nothing to stop the persistent wind that whistles up Tucker Gulch from the southwest and whips the bunchgrass on the open ridges. Many Montanans are familiar with the feel of a cold draft that somehow comes through the walls of old houses and sends a chill up the spine. There is none of this in the McCauley house. Walls 13 inches thick and full of fiberglass insulation, triple-pane windows, a polyethylene air-vapor barrier inside the walls, a Tyvek air barrier under the siding and careful caulking of all seams and joints keep the outside weather outside. Even the sound is excluded. "If we don't look out the window, we don't know the wind is blowing," Dan Said.

Taking a bite out of energy bills: the McCauley house is impervious to wind and cold. Note roof overhang letting the sun in on the day the photo was taken, October 26

Efficiency and Livability

Energy efficiency and overall livability were on the McCauleys' minds when they had their house built in 1984. Livability was enhanced by cedar siding, cathedral ceilings, a deck around two sides of the house, and big windows looking out over vast expanses of blue sky and native forest.

An EMR 250 heat recovery ventilator controls indoor air quality. The McCauleys run the ventilator manually when needed to ventilate the bathroom or kitchen, and they set their dehumidistat between 35 and 55, depending on the outside temperature. The long axis of the house faces slightly west of due south, and the glazing on the southwest side helps heat the house. When the sun is not enough, the McCauleys can turn on their electric baseboard heaters. "We don't turn on the baseboards at all for five or six months of the year," Dan said. A 38-inch overhang keeps the sun out of the windows during the warm months when it is not needed.

Heating on Less than $200 per Year

The McCauley house is built to the energy-efficiency standards of the Residential Standards Demonstration Program, sponsored by the Bonneville Power Administration and the Montana Department of Natural Resources and Conservation. This program reimbursed homebuilders for the cost of energy efficiency measures above those required by HUD standards (see Glossary), and monitored energy consumption to see how it

Owners
Dan and Cheryl McCauley

Location
South of Helena

Designer
Owners

Builder
Glen Voelkel
7535 York Road
Helena, MT 59601
475-3615

Style
1 Story Full Daylight Basement

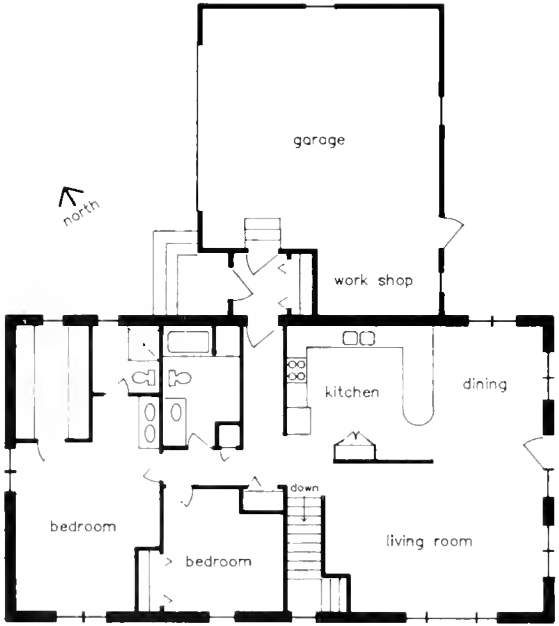
Insulation
Ceiling - R60
Double Walls - R41
Basement - R41
Slab - R5

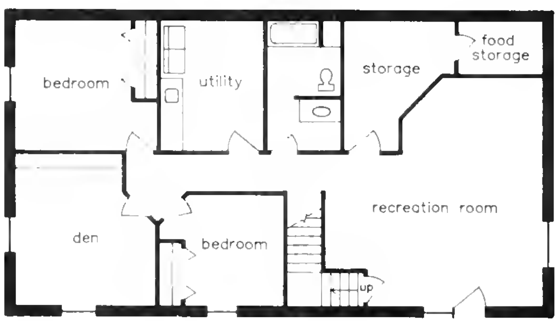
Square Feet
Main - 1 620
Basement - 1 620

Special Features
RSDP Construction
Superinsulation
Triple-pane Windows
Cathedral Ceiling
Raised-heel Scissors Trusses

Heat
Passive Solar, Electric Baseboard

Completed
September 1984





compared with that of HUD houses. The McCauley house used 3,380 kWh of electricity for heating during the year from April 1985 to April 1986. The Montana Power Company electricity rate of approximately $.05 per kWh brought the McCauleys' heating bill for that year to about $169. Houses built to HUD standards tend to require about 3 times as much heat per square foot as RSDP houses. At this rate it would have cost about $533 to heat the McCauley house for a year if it had been insulated only up to HUD standards. □

Scissors trusses make room for a cathedral ceiling. Note mid-day sun through south window at right.

Superinsulation Keeps House Cozy

For Dave and MaryLynn Ramsey, the Sunhaven subdivison where they live on the west side of Helena is appropriately named. Snow might be a foot deep and the outdoor temperature registering a chilly 10 degrees, but the visitor passing through the wooden front door and the airlock entry of the Ramseys' house leaves street noise and cold behind. Warmth and quiet take over. From the entryway, a short flight of stairs leads up to the main floor or down to the walk-out basement.

Sun Keeps House Comfortable

Upstairs in the main living area, MaryLynn gestured to the south-facing windows. "We turn the heat down during the day when we're gone. But the sun coming in through those windows keeps the house at a comfortable temperature. When I come home for lunch, I usually don't have to turn up the heat if the sun has been shining." MaryLynn also noted that they were just a few hundred feet from the Burlington Northern tracks. "We don't hear the trains go by except in the summer. When we open windows, we really hear the outside noise."

Rooftop solar collectors on a Helena house the Ramseys lived in previously convinced them of the sun's effectiveness as a heat source in the area. They weren't about to own a house that didn't take advantage of it. "We left Helena for awhile," MaryLynn said. "We returned and were shopping for another house, and had just about given up finding what we wanted. Then Dave stopped to visit a carpenter friend who was working for a contractor on a house-building crew." The Ramseys liked this house their friend was working on. They liked the style, and the construction quality, and they liked Bill Pierce, the contractor.

Four large south-facing windows admit free heat from the winter sun to Dave and MaryLynn Ramsey's house in Helena. Slatted wooden awnings above each window turn away hot summer sun.

Quality Construction

For the Ramseys, the building contractor was an important element. "We didn't want a builder who would just throw a house together," MaryLynn said. "This house proved Bill does a good job, and we were pleased when he was voted 'Builder of the Year' in 1985."

After living in the house for over three years, the Ramseys are still enthusiastic about it. Double walls with three fiberglass batts, a 6-mil polyethylene continuous air-vapor barrier, and a thick layer of cellulose ceiling insulation team up to trap the heat from the sun streaming in through the south-facing windows. Three inches of compacted gravel form the base of the basement slab. A 6-mil polyethylene moisture barrier was

Owners
David and MaryLynn Ramsey

Location
Helena

Designer
MASEC Center
8140 Twenty-sixth Avenue South
Minneapolis, MN 55420

Builder
William Pierce
Pierce and Associates
1424 Dodge Avenue
Helena, MT 59601
443-4637

Style
Split Entry

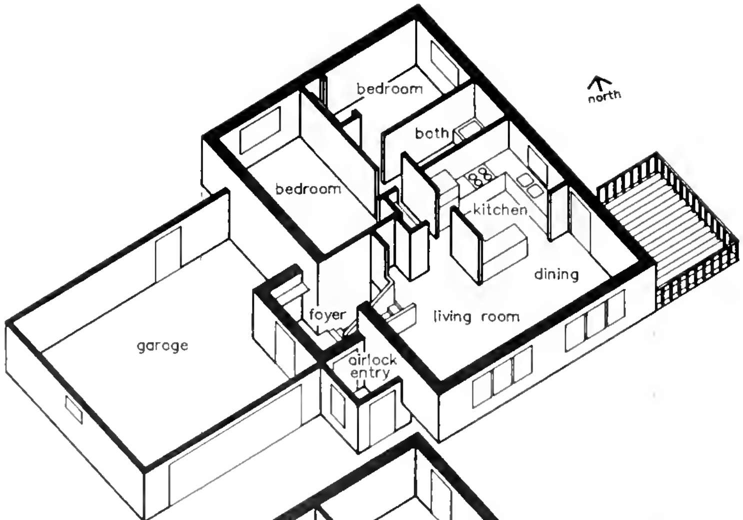
Insulation
Ceiling - R69
Double Wall - R41
Basement Wall - R26
Slab - R7

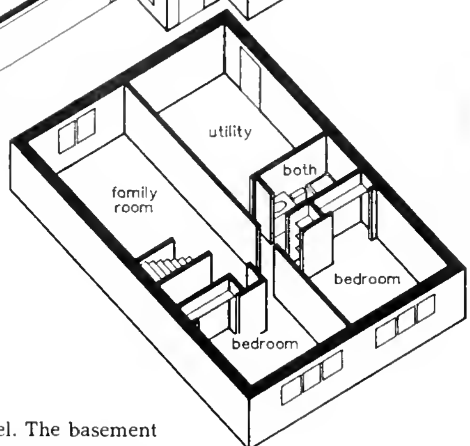
Square Feet
Main - 1,146
Basement - 988

Special Features
RSDP Construction

Heat
Electric Baseboard

Completed
1984





placed over the gravel. The basement slab was installed on 1 1/2-inch extruded polystyrene laid over the poly. Three inches of extruded polystyrene was installed on the exterior of the concrete basement walls.

Of the 154 square feet of windows, 84 square feet face south. All windows are triple-glazed Pella with wood casements. The airlock entry is a real treat for the Ramseys. "It certainly stops the winter cold or summer heat from blowing into the house when we open the front door," MaryLynn said. "It helps make living here very comfortable."

Solar Gain Needs Open Area

MaryLynn pointed out the house's location. "We didn't think about the setting when we bought the house, but we're fortunate that it happened to face an open area that won't be built on. This is something people building in subdivisions need to consider if they are facing their house for solar gain."

Working With the Ventilator

Living in a tight house has taken some adjustment, primarily with the heat recovery ventilator. One of the first on the market, the ventilator didn't have a defroster. "And," MaryLynn said, "its intake was installed just above the outlet of the dryer, so the ventilator was picking up moisture and bringing it back inside." These drawbacks were aggravated by the house being finished in the fall with no time for the construction materials to dry before winter set in. "The condensation ran off the windows and puddled on the sills, and the ventilator froze up that first winter," MaryLynn said. "The installer came back and switched the ventilator's exhaust with its intake. They also streamlined the ventilator ducts and balanced the air intake and exhaust. It helped a lot."

Time has also helped. "We've had much less moisture this winter than we had the previous three winters," MaryLynn said. "Tell people, these houses do dry out. We watch the weather and humidity closely. When it's bitter cold, we try not to run the ventilator in the evening. Seems like when we're bringing in such cold air from the outside that we're defeating our heating system. We try instead to run it during the night, or on days when we're not home."

Heating Considerations

The Ramseys' 20,000 Btu heating system consists of 36 feet of electric baseboards for a total of 9,000 watts. A thermostat in each room tailors the heat for what's needed. "We're experimenting in the two downstairs bedrooms," MaryLynn said. "The rooms seem to stay warm without much aid from the baseboard heaters but it may be from heat in the waterbeds. I'm thinking it may be cheaper to keep the room warmer using the baseboard heaters rather than heating the rooms with the waterbeds."

RSDP Program Provides Records

The house was part of the Residential Standards Demonstration Program, so the Ramseys have precise records of utility bills. The first year they used 16,076 kilowatt-hours. Space heating took 2,960 kWh, 6,080 went for water heating, and 7,036 was for lighting, cooking, and refrigeration. "Our hot water use seems high, but we do have three children," MaryLynn said.

At an average rate of 5 cents per kilowatt-hour, however, the annual bill for everything amounts to $803 or about $67 per month.

Low Power Bills Initiate Interest

It's taking time, but energy-efficient construction is becoming more of a topic of conversation among the Ramseys' acquaintances. "People aren't especially interested in our 12-inch-thick walls until they find out what our power bills are. Then they become very interested," MaryLynn said with a laugh. "We think our bills are high until we start comparing with others who don't have energy-efficient houses.

"We love this house. It's a lot more comfortable than any house we've ever lived in. We don't get the terrible cold drafts. We'd be glad to share information with others interested in buying or building an energy-efficient house." □

Window openings clearly show the thickness of the walls. Three layers of fiberglass batts between the 12-inch double walls are part of the superinsulation package protecting this house from the ups and downs of Montana's weather

Finnish Fireplace Backs Up Solar

Owners
Tom Ryan and Heidi Goldman

Location
Helena

Designer
Tom Ryan and Heidi Goldman
Ryngold Enterprises
Helena, MT 59601
449-8150
Rick Schlenker, Architect
46 South Last Chance Gulch
Helena, MT 59601
442-3943

Builder
Owners (Ryngold Enterprises)

Style
2 Story

Insulation
Ceiling - R45
2 x 6 Wall - R25
Lower Wall - R8 7

Square Feet
Main - 1,300
Lower - 1,300

Special Features
Post-and-Beam Construction
Thermal Storage
Active Solar Water Heating
Finnish Fireplace
Outside Combustion Air

Heat
Passive Solar, Wood, Electric

Completed
May 1985

West of Helena where the county road ends in Colorado Gulch, a private road continues, climbing a steep hill. It stops at a distinctive house that overlooks a deep forested ravine. Here, Tom Ryan, his wife Heidi Goldman, and their young son, Sean, live with nature and quantities of quiet. "Deer bed down in the yard," Tom said, "and in the spring—bear come around practically knocking to get in."

House Uses Local Materials

In this idyllic setting, Heidi and Tom have built a house that expresses their ingenuity and self-sufficiency. Tom and Heidi, who own the construction firm of Ryngold Enterprises in Helena, built the house over 3 1/2 years, using Montana materials and employing local craftsmen. Native pine, Douglas fir, and aspen cut from the surrounding forest provide framing, paneling, doors, and trim for the house. Brick rescued from the demolished railroad roundhouse in Helena lends its pinkish-gray tones to an arched enclosure for a wood stove in the daylight basement. A Finnish fireplace on the main level was built with sandstone hauled from the Monarch Mines near Great Falls.

Sawmills at Canyon Creek and at Lincoln cut native logs into framing pieces and paneling. Chris Yahvah in Colorado Gulch built the oak kitchen cabinets, and Joyce Davis of Helena crafted the leaded glass cabinet doors. Ron Pihl of Pray, Montana, built the Finnish fireplace.

Large south-facing windows allow the sun to reach across the open rooms of both floors. The 5-foot overhang and deck keep the summer sun out. Solar panels on the roof (top left) heat domestic and space-heating water.

Post-and-beam Shoulders Load

Drain tile surrounding the house carries water away from the foundation. On the exterior of the concrete basement walls, two coats of fibrous asphalt, 2-inch extruded polystyrene, and a 6-mil polyethylene vapor barrier keep heat in and water out.

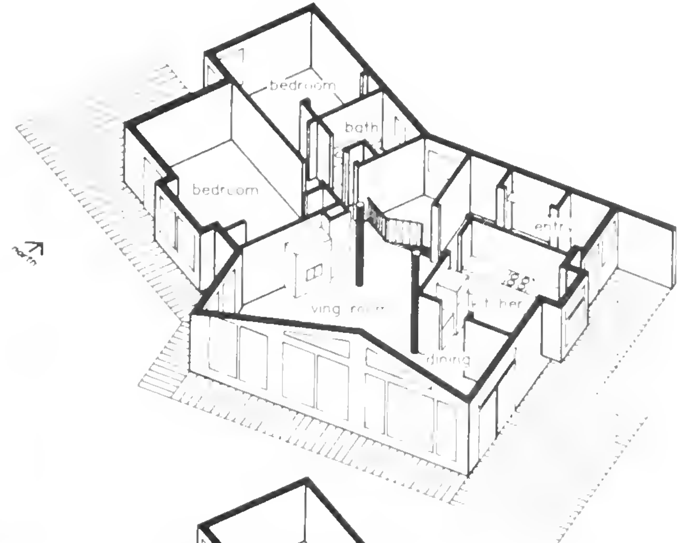
Tom ran his hand over the post in the center of the daylight basement. "We combined post-and-beam and conventional 2 x 6 framing," he said. "This post stands 22 feet high from here to the rooftop. The base is 14 inches across." He pointed out the exposed girders and joists supporting the second level floor. "Those are full rough-cut 2 x 10s. Notice that the entire frame is notched and pegged. We did it all by hand—drilling, sawing, and chiseling."

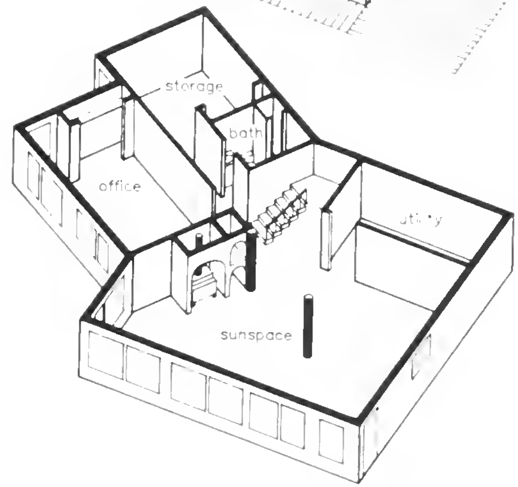
Balusters and hand rails of peeled logs follow the spiral staircase connecting the two levels. Above the main living area, six heavy log beams radiate from the center post to support the 14-foot-high sloped ceiling.

Walls are framed with full rough-cut 2 x 6 studs and insulated with 5 1/2-inch fiberglass batts. An air-vapor barrier of 1/2-inch polyisocyanurate board and 6-mil polyethylene was installed on the interior under the drywall. On the exterior, a Tyvek air barrier was placed between the 3/4-inch plywood sheathing and 3/4-inch cedar siding.

South-facing windows afford a dramatic view of forested canyons and mountains, and admit heat from the sun.

Two fans in the archway enclosing the basement stove push heated air into the room through openings in the brick. A paddle fan over the stairwell pulls the heated air upstairs. The stove's brick enclosure absorbs heat and radiates it as the room cools.





The ceiling comprises several different materials. An air-vapor barrier of 1/2-inch polyisocyanurate foam board and 6-mil polyethylene was installed between the ceiling gypsum board and the rafters. The seams of the foam board were taped. The 2 x 12 rafters provide room for 9 inches of fiberglass and an airspace. A 4-layer roof was installed over the rafters: 5/8-inch plywood sheathing, 2-inch extruded polystyrene, 3/8-inch plywood, and felt-asphalt seal-down shingles. Seams between the plywood sheets were sealed with fibrous asphalt.

The subfloor consists of 1 x 6 tongue-and-groove pine installed over 2 x 10 floor

joists with 1/2-inch plywood laid over the pine. Both pine and plywood were glued and nailed with ring-shanked nails. Thirty-pound asphalt felt was stapled to the plywood. For the kitchen floor, expanded metal lath was tacked to the plywood and filled with thin set mortar. Once the mortar hardened, Mexican blue ceramic tile was set into a second adhesive layer of mortar. Tom explained that the sturdy base allowed the wood floor to expand without cracking the mortar. The rest of the main level floor is tongue-and-groove oak, except the bedrooms, which are carpeted.

Thermal Mass Stores Solar Heat

An integrated system using solar, wood, and electricity heats the house. "We use three cords of wood annually, and our maximum monthly electric bill has been $30," Tom said.

The first line of defense against winter's cold is the large bank of south-facing windows on both upper and lower levels. The basement's thick concrete walls and floor soak up the heat from the sun streaming through the double-glazed windows.

"We get a tremendous amount of solar gain in the winter," Tom said. "The temperature can be twenty below outside, but as long as the sun is shining, the house will warm to 85 degrees just from the heat coming through the windows. If the sun shines for several days, we don't need any other heat, even at night. We've had bright, sunny days with temperatures in the minus twenties, and the house gets so hot, we have to open windows and doors."

Post-and-beam construction minimizes interior supporting walls. The open space offers good air circulation.

A tile-lined sill separates the sink from an east-facing window box planter. The sill frame is rough-cut 4 x 6s, notched and pegged. The bottom of the plant box is a stainless steel pan with a copper drain. Because the window box extends outside the house, the pan is insulated underneath to prevent heat loss.

Wood Stove Provides Quick Heat

On cloudy days or cold nights, quick heat comes from the wood stove in the basement. The back of the brick enclosure around the stove forms one wall of Heidi's office. "That room gets so much heat from the sun and from what the brick radiates that I've never had to use the baseboard heaters," Heidi said.

Finnish Fireplace for Steady Heat

"When we expect a cold spell, we crank up the Finnish fireplace in the living room," Tom said. "It takes a couple of days and some attention to get maximum heat from it, but after that we need only a small fire just once or twice a day, and we don't stoke it at night."

He opened the cast iron doors of the fireplace. "The first fire is small. We start with some kindling, paper, and a few sticks of 4-inch diameter wood. The second, built about 6 hours after the first, is somewhat larger. The third fire consists of about 30 pounds or a good armload of wood. It really rips." Building the fire in stages warms the mass of brick and stone slowly which prevents cracking from sudden expansion.

"Once the third fire is blazing, we close the main outlet draft, forcing the exhaust gases into two 3-inch-wide channels down the sides of the fireplace to the chimney. As the hot exhaust gases pass through the channel, the stone absorbs a lot of heat which radiates slowly into the living space. If we want direct heat, we can always damper the fire and open the fireplace doors." Combustion air from outside enters the fireplace through a duct.

Fans Distribute Heat

A plenum with two fans over the hallway does double duty. In the winter, one fan draws hot air from the ceiling to the basement. "When the temperature rises above 75 degrees," Tom said, "the fan kicks on."

In the summer, the other fan pushes the hot air out through a ceiling exhaust. "We can open upstairs windows to let the hot air out, and open downstairs windows on the shaded side of the house to bring in cool air," Tom said. "We have no dead air spaces; the fans keep it moving. We use rheostats to regulate the fan speed."

Small fans over the doors pull air into the bedrooms.

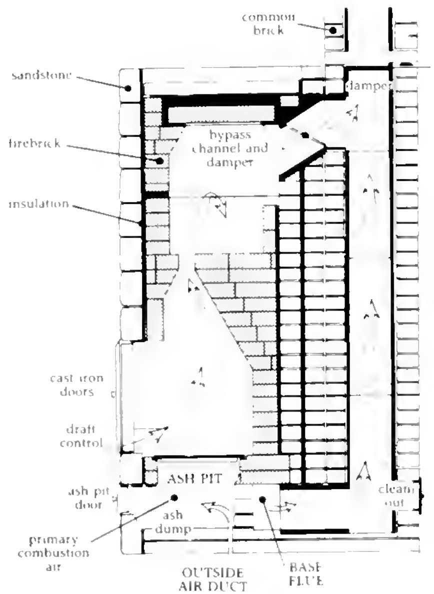
Solar-powered Hot Water

Solar collectors on the roof provide most of the heat for the hot water. The system pumps water from a well to a holding tank in the basement mechanical room, and then to the roof panels and back. The water passes through glass tubes in the solar collectors, soaking up heat from the sun, and then moves through a heat exchanger in a 120-gallon tank. Water from this tank flows to a 55-gallon electric water heater, which kicks on during long periods of overcast weather. "Even on overcast days, we get some solar preheat," Tom said

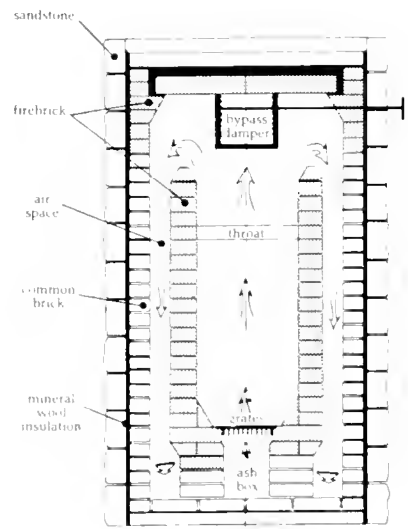
Sensors and a digital readout in the mechanical room track the water's temperature from well to roof, from roof to tank, and in the 120-gallon storage tank. When the sun goes down, or if power fails, all water automatically drains from the glass tubes into a third tank in the

The Finnish fireplace was the first in Lewis and Clark County and only the fifth in Montana. Except for the upper and lower flue connections, the fireplace is separate from the chimney (right) and the wall behind, which lets the fireplace expand and contract freely. It takes just 3 cords of wood a year to heat the 2,600-square-foot house.

The Finnish fireplace has a main chamber where burning occurs; a second chamber above where additional heat is absorbed into the masonry. The top of the main chamber narrows to a small passage connecting the main chamber to the chamber above. The chambers are built without square corners so the hot gases roll and tumble, getting as hot as 1,600 degrees. Hot gas leaves the second chamber through a pair of narrow channels that lead down the sides of the structure, and then rise to join the flue. As the superheated gases move through the channels, the brick and sandstone shell absorbs the heat. The absorbed heat is radiated gradually from the brick and sandstone to the living area.



SIDE CROSS SECTION



FRONT CROSS SECTION

mechanical room. To prevent breakage of the tubes after a power failure, a sensor measures the difference in the temperature of the glass tubes and the temperature of the water in the holding tank. If the empty tubes have become too hot from the sun beating down on them, and the water has cooled substantially, the sensor prevents the system from pumping the cooler water to the hot tubes once power is restored.

Water also can be heated by the fireplace. A pipe-looped heat exchanger in the back corner of the Finnish fireplace connects to the water circulation system. "This is convenient on cloudy days when the fireplace is roaring and there isn't much sun," Tom said.

Hot Water Heats House

The solar panels also play a role in space heating. "With the flip of a switch, I can use the system to heat the water circulating through a register," Tom said. "If we're gone during cold spells, we're not using hot water for showers or dishes, so we use it to keep the house warm."

Installed by Suncraft of Bozeman, the solar water heating system has been virtually trouble free since its installation in October of 1984. "We replaced a relay that went out," Tom explained. "Then later that year I was clearing snow from the roof and broke a tube. The distributor sent a new tube immediately."

Many Cultures Meet in House

The house is as pleasing to the eye as it is efficient. Richly colored furnishings from other cultures accent the warm patina of the timbers and paneling. In the airlock entry, large bronze floor tiles from Mexico harmonize with the pine walls. The white walls and ceiling of the living area dramatize the heavy timber construction and diffuse the light streaming through the ceiling-to-floor windows.

A large woven rug from Nepal hangs on the stairway wall. Its blue tones echo the blue of the living room's peach and blue couch and pillows. The foyer is accented with delicate oriental vases of blue and ivory. Smoky-blue tiles from Brazil gleam cooly on the kitchen countertops and backsplash. Intricate dark-blue patterns etch the tile faces, the result of leaves and petals pressed into the wet clay, then burned out when the tiles were fired.

Plants spill over the head-high wall between kitchen and dining area. Beneath the oak dining table, handcrafted in France, a rug from India adds to the charm of the house.

Heidi said many of the pieces came from tours she and Tom conducted for clients of the Feathered Pipe Ranch, a center for workshops and retreats that promote mental and emotional harmony and health. Journeys have taken Tom and Heidi to Central America, India, Nepal, Russia, the West Indies, Mexico, and Jamaica

Setting an Example

The payoff from Tom and Heidi's house is more than simply saving money on fuel. They have the satisfaction of living in a home designed to use renewable resources. "People who attend the seminars at the Feathered Pipe Ranch visit our house and remark on its beauty and efficiency," Tom said. "These people come from all over the world. It's nice to show others what can be done." □

The center of a steel spider-like brace is anchored to the support post. Pegs fasten a steel leg into each of the six beams.

Sun, Fans, and Superinsulation Keep House Warm

A striking, new three-story house perches on the flank of a hill amid the vintage residences on Helena's south side. Although the house is obviously new, its blue-trimmed bay windows, cupolas, and many roof peaks fit the Victorian character of its older neighbors. What sets it apart is hidden from outside view.

From footings to roof, the house was planned for energy conservation. Owners Frank DiNenna and his wife, Julie Wulf, heat and cool the house's 4,500 square feet for less than $300 a year without sacrificing comfort or view. "Even with the many north-facing windows, our house keeps an average temperature of 65 degrees during the winter with little help from the furnace or wood stove," Frank said.

In spite of the many north-facing windows, the 4,500 square foot house is heated and cooled for less than $300 a year.

Geared for Comfort

The house is an integrated package of energy efficiency, comfort, and aesthetics. An insulated 1 3/4-inch steel Peachtree door opens into an airlock entry. The clean scent from tongue-and-groove cedar paneling and the warm sheen of the bronze-toned tile floor welcome the visitor. The entry opens to a daylight basement and to polished stairs ascending to the main living areas above.

Bay windows on the north wall of the first and second stairway landings afford expansive views of the mountains and Lake Helena across the valley. The natural light falls on colorful batik hangings decorating the walls.

All windows are double-glazed Pella. The large windows have a 1-inch air space between panes, the smaller casements a 3/4-inch space. The operable windows are hinged at the center so the exterior surface can be rotated and cleaned from inside the house. The spaces in the rough openings around the windows and doors were caulked with silicone.

Frank pointed to a cat sleeping on a pillow in the window seat of a north-facing bay window, and to the Golden retriever on the blue carpet below. "If there were any drafts, those animals wouldn't be there; they'd be warming themselves by the wood stove."

Rooms Share Light, Heat

On the second floor, the use of laminated beams kept interior support structures to a minimum. The living room, kitchen, and dining area share a large open space. Across the south side, French doors provide access to the outdoor patio and deck, and admit light and the sun's heat. A Kent tile wood stove occupies a small cubicle at the west end of the living room. Combustion air for the stove is piped directly from the outside to the firebox. "We use the stove on cloudy or cold days, but we burn less than a cord of wood a year," Frank said.

Owners
Julie Wulf and Frank DiNenna

Location
Helena

Designer
Frank Cikan
205 West Main Street
East Helena, MT 59635
227-6025

Builders
Frank DiNenna
Box 1251
Helena, MT 59624
443-6251
Bradley Chase
Boulder, MT 59632
Lanny Stubson
Coram, MT 59913

Style
3 Story

Insulation
Ceiling - R38
Double Walls - R33
Basement Walls - R21

Square Feet
4,500

Special Features
Sunspace
Fan-assisted Air Circulation
On-demand Hot Water Heater
97% Efficient Furnace
Outside Combustion Air

Heat
Passive Solar, Natural Gas, Wood

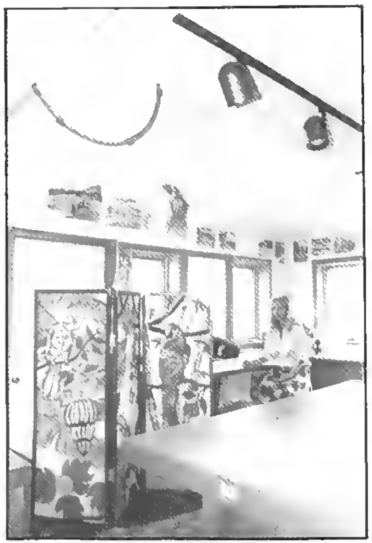
Completed
December 1985

A sliding door from the dining area leads to a sunspace. The terra-cotta tile floor of the sunspace soaks up heat from the winter sun and releases it when the sun goes down and temperatures drop.

In Julie's batik studio adjacent to the sunspace and kitchen, a vaulted 16-foot ceiling and banks of windows admit abundant east and south light. The bronze-colored tile floor collects the sun's warmth.

The master suite on the third floor includes a spacious bedroom, large bathroom, an oversized shower, Jacuzzi, and laundry facilities. "Even with the plants, the shower, and the Jacuzzi, we have absolutely no condensation on the windows," Frank said. He indicated the chest-high wall and the sunspace below. "Leaving the third level open to the sunspace provides excellent air circulation."

The utility room is next to the master bedroom and bath. "Most of the laundry comes from these rooms, so I put the washer and dryer here instead of in the basement," Frank said.



A lot of moisture is generated by the dyeing of materials in Julie's batik work. The large volume of space enclosed by the high ceiling promotes good air circulation and prevents condensation on the windows.

Construction Traps Heat

Beyond the surface of the house's ivory walls and ceiling lies the secret to the low heating bills. The basement walls are furred out with 2 x 4 studs and insulated with foil-backed fiberglass. The exteriors of the concrete basement walls are sheathed with 2-inch extruded polystyrene foam board to the footings. "I inserted 10-inch L-shaped flashing underneath the siding and slanted it over the top of the foam board to prevent water from flowing down behind the insulation and freezing," Frank said

The second and third stories are framed with double stud walls—a 2 x 6 wall on the outside and a 2 x 4 wall on the inside—which provide room for 10 inches of fiberglass insulation. The two-wall construction provides a thermal break, stopping conductive heat loss. The attic is insulated with 12 inches of unfaced fiberglass batts. A continuous air-vapor barrier of 6-mil polyethylene minimizes the movement of air and moisture from the house.

Hot Water and Ventilation Integrated With Furnace

Frank called attention to the 97-percent-efficient condensing Amana gas furnace. "It vents through a plastic pipe out the side of the house, and the

Ferns, philodendrons, and ivy flourish in the natural light streaming into the sunspace. Heat from the sunspace circulates to the adjacent living area, and to the third floor.

Tile lining the walls of the wood stove enclosure reflects the stove's heat to the living area. When the temperature of the enclosure reaches 98 degrees, a small fan above the stove, concealed behind wooden louvers, turns on to push the heated air into the living room. The louvers direct the warmed air to the lower, cooler areas of the room.

In the dressing room-bath area, a half-wall (center of photo) encloses the opening to the sunspace below. The angled ceiling and fans concealed above doors direct warmed air from the sunspace into the third level master suite. On the east wall of the bathroom, a stained glass window and a small fan bring in light and heat from the studio.

condensation runs through a small pipe into the sewer drain. No chimney meant one less hole in the roof that heat could escape through."

Next to the furnace a small tank brings water to room temperature for the on-demand hot water heater. When a hot water tap is opened, the furnace burner kicks on to heat the water flowing through a pipe in the furnace. The flow rate controls the size of the burner flame. "We can have three showers going at once without running out of hot water," Frank said. Both the furnace and gas kitchen range have electronic ignitions rather than pilot lights.

The air supply for a heat recovery ventilator is integrated into the furnace ducting. As the ventilator draws in air from outside, the air mixes with warmed air in the ducts before being distributed to the rooms.

A small computer controls the integrated system. When the temperature in the house drops below the thermostat setting of 65 degrees, a sensor triggers the computer to turn on the furnace.

Most of the time, the ventilator is controlled by the dehumidistat, but the computer can be programmed to turn on the ventilator at any hour of the day for any length of time. Timers in the kitchen and bathrooms can override either the dehumidistat or computer-programmed setting on the ventilator. "If we're cooking or having a party and want to freshen the air," Frank said, "we simply turn on the kitchen timer. It takes about 5 minutes to get rid of the odors, including all the cigarette smoke. And it's whisper quiet. On sunny days, when there is more coming and going of pets and people, we often shut off the ventilator completely," Frank said.

Rheostats Contribute to Quiet Fans

Frank had other ideas for better energy management. Installing rheostats on the wall fans, which provide infinite control of their motor speed, reduced fan noise to a whisper. "At slow fan speeds, the air circulates better and the fans are much quieter," Frank said.

Saving steps was another goal. Switches in the kitchen and studio open the garage door to admit visitors. Intercom speakers throughout the house, including one by the first floor entry, keep family members in touch or let them talk to visitors before opening the door.

Energy Savings Extend to Garden

Future plans call for adding to the natural beauty of the wild roses and other native flowers and shrubs around the house. Frank said landscaping will be low-maintenance. Spruce trees will deflect winter winds; deciduous trees will shade the house, although the roof overhang shields the house from most of the hot summer sun.

"I positioned the house for the very best view, probably the best in Helena," Frank said, "and I designed the house around Julie and her art. But, I also designed it to be totally efficient and hassle-free. Considering the $180,000 value of the house, the extra $3,500 in materials for the energy-saving features was a bargain." □

A Dome in the Woods

Owners
Jim and Janet Livingston

Location
Heron

Designer
Cathedralite Domes, Exterior
George Paul Swanson, Interior
P.O. Box 6548
Bellevue, WA 98007
(206) 643-0100

Builder
Cathedralite Domes (Pre-fab)
(Address not available)

Style
Dome with Loft

Insulation
Dome - R11
Vertical Wall Segments - R15

Square Feet
Loft - 700
Main - 1,650

Special Features
Dome Design
Wood-Electric Furnace
Crawl Space Plenum

Heat
Passive Solar, Wood, Electric

Completed
1980

When Jim and Janet Livingston decided they needed a new house, they knew they weren't going to be limited by conventional notions of what a house ought to look like. A display they saw at a home show in Portland, Oregon, convinced them that a geodesic dome was just what they needed. The kit they ordered for a 45-foot diameter dome consisted of 60 pre-built triangles designed to be bolted together to form the shell of the structure. Jim said it took only one day for a crew of amateurs to assemble the shell, but another two years to complete the interior. Today, the house looks right at home in its location in a forest clearing, just on the Montana side of the Montana-Idaho border near Heron.

"I'd never build another home myself," Jim said, recalling the time and effort required. Nevertheless, the Livingstons said, it was worth the effort, and their dome house provides them a bright and comfortable living space.

Construction methods for building energy-efficient houses have changed substantially since the Livingstons began assembling their geodesic dome in 1979. Even then, techniques were changing so rapidly they knew they couldn't keep up. Consequently, the Livingstons' house is not as energy efficient as it could be if it were built today. As an example of changed practices, Jim recalled that 10 years ago, continuous air-vapor barriers were not commonly installed, and the Livingstons did not put one in.

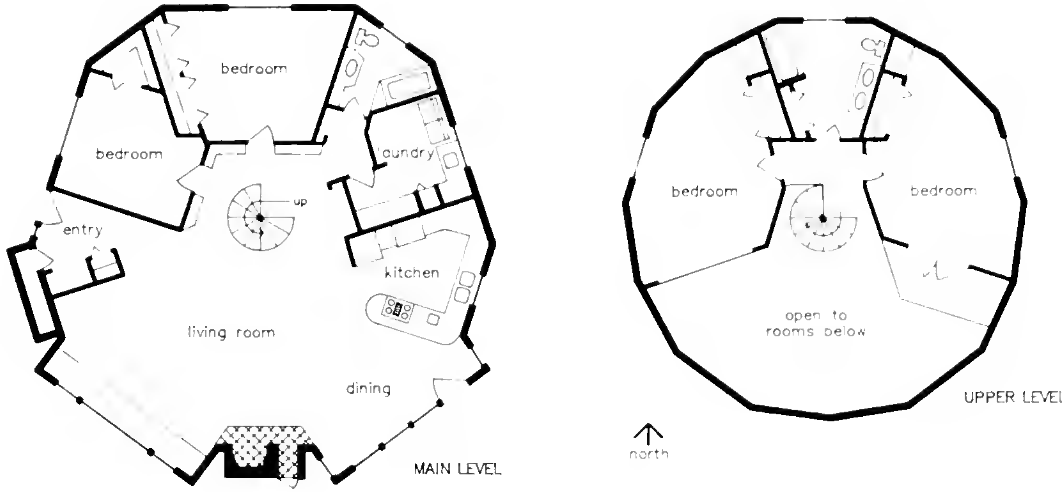
The Livingston house sits just inside the Montana border near Heron. Woods at left are in Idaho.

Large Windows Brighten, Warm Interior

The inside of the house is brightened primarily by the large windows on the south and west sides. These help warm the house by admitting sunlight, but also cause a heat loss to the outside in cold weather when there is little or no sun. The Livingstons are reluctant to add curtains or other equipment to reduce heat loss because they don't want to detract from the windows' attractive appearance. Jim said that even in winter, the sun provides heat. "We often manage two or three days in dead winter without any heat, if we have clear days and a snow pack for the sun to bounce off," he said. "It may be 60 degrees inside in the morning, but it will get to 80 degrees by 4 in the afternoon." All the windows are standard double pane.

The inside of the house is mostly open space, with bedrooms and bathrooms arranged around the perimeter. The main floor has 1,650 square feet, with an additional 700 in the loft. All this space is heated with an ELF wood-and-electric furnace from Traeger Heating of Mt. Angel, Oregon. This forced-air, zero-clearance furnace blows hot air into the crawl space. Warm air rises from the

crawl space through vents in the floor into the living space. The walls of the crawl space are insulated with R19 fiberglass batts. The floor of the space is a 6-mil black polyethylene moisture barrier over pea gravel. In the winter the Livingstons cool their house by reversing the furnace fan and drawing cool air from the ground. Jim noted they did not have a high groundwater table. (DNRC building specialists suggest that the energy efficiency of this type of system can be improved by insulating the ground in the crawl space to prevent heat loss to the soil. Also, heating systems using unsealed crawl space plenums are not appropriate where soils release radon gas or in areas with high groundwater. Groundwater is an effective heat conductor and can steal heat if it is within 10 feet beneath an uninsulated crawl space plenum.)



South windows in the Livingston house collect both warmth and light, and provide a bright and comfortable interior environment.

Wood Furnace Supplements Sun

Jim Livingston said wood provides 98 percent of the space heat not provided by the sun. He said they only use the electric furnace when they are gone for several days in cold weather. They normally stoke the wood furnace in the morning before they go to work, and once warm, the house holds heat well. Inside temperatures have never dropped below 60 degrees while the Livingstons are gone during the day, Jim said. Besides the furnace, the Livingstons also operate an antique wood-burning cookstove "to take the chill off." Jim said they use about 4 cords of wood per year in the two wood-burners.

The lack of corners in the house helps distribute the heat evenly and prevent cold spots. The openness of the living space allows much of the warm air to rise to the top of the dome, where a ceiling fan directs it back down. A turbine vent near the apex of the dome makes it easy to let warm air out of the house when necessary. The reversible ceiling fan is near this vent, and can be operated either to blow warm air back down or to help pull it up so it can escape through the vent.

A Pleasing and Efficient Design

Wall framing in the house is single 2 x 4 stud wall. The vertical wall sections are insulated with 3 1/2-inch, R11 fiberglass batts, with half-inch, (R3.65) polyisocyanurate boards under the drywall. Insulation in the curved dome section is standard R11 fiberglass batts. The interior of the dome is beautifully decorated with artworks, and a fine oak parquet floor imparts a feeling of warmth and quality. The many angles in the dome structure

provide a pleasing variety of visual aspects on the interior. A spiral staircase rising from the center of the lower floor to the loft also pleases the eye.

The dome shape is by its nature more energy-efficient than rectangular structures. The geometry of curved surfaces provides less external surface for a given amount of floor space than a rectangle does, so there is less area to radiate heat to the outside. Literature from the Cathedralite Domes manufacturer says that a dome has 38 percent less exterior surface than a rectangle with the same floor space.

Pond Provides Cooling, but Requires Debugging

The Livingstons obtain a measure of summer cooling from a pond just west of their house. This pond also generates a good crop of mosquitos, but the Livingstons eliminated the bug problem by installing numerous bird houses. The many martins, sparrows,and bluebirds that nest in the houses take care of the bugs, Jim said.

Some Minor Improvements Possible

Jim said that he and his wife like the dome configuration of their home. If they were to build it again, he said, they would put in an operable skylight so a roof repairman could get out on the dome roof from inside the building. This would make it much easier if roof repairs were needed, Jim said, recalling how difficult it was to get on top of his dome to repair a small leak near the apex.

Construction of the shell, along with the excavation and concrete necessary for the construction, cost about $60,000, Jim said, with another $20,000 needed to finish the house.

Domes Still Available

Although the dome building enthusiasm of a few years back has waned, pre-built dome shells are still available from various manufacturers. Some of these can be obtained with optional 2 x 6 framing and rigid insulation up to current standards for energy efficiency. Anyone interested in domes should check the advertisements in national magazines that have to do with nonconventional housing, such as Mother Earth News. The Cathedralite line of domes is either out of business or operating under a different name, and could not be located by DNRC. □

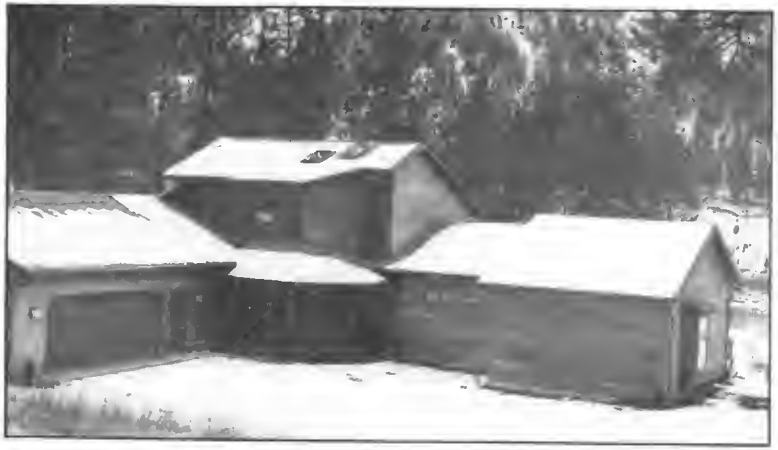
The interior geometry of dome houses presents many odd angles and surfaces that lend themselves to creative decorating.

Elegant Design Accommodates People and Energy Savings

With eight grown children and numerous grandchildren descending upon them periodically, Gregg and Doris Johnson had some priorities. "We wanted a big house comfortable for two or twenty and, having lived with those eight kids, we knew we needed a sanctuary for ourselves," Doris said. "We also had to do something to keep the heating costs down since we were going to be all electric," Gregg added.

"After seeing many houses and studying many plans, we had my nephew, who is a designer, pull our ideas together," Doris said. "Then Gene Clawson Jr. of Clawson Windows in Missoula referred us to Steve Loken and John Lentz of Southwall Builders who were experienced in building energy-saving houses. Steve and John got the house accepted into Montana's Residential Standards Demonstration Program."

While the house was being designed, Gregg, a scientist with the U.S. Forest Service's Intermountain Fire Sciences Laboratory in Missoula, was in Australia on special assignment. "I didn't have any materials there, so when Doris would send me the plans, I would construct cardboard models using beer cases." Emerging from these primitive beginnings, the house is an impressive cedar beauty sitting on the banks of the Clark Fork.



Multiple roof lines, two octagonal windows, and a sheltered corner entry create an appealing welcome for the visitor to Doris and Gregg Johnson's house. A two-car garage buffers the east wing from cold north winds, and provides access to the kitchen through the utility room.

Main Rooms Face Sun

The house is designed and placed for optimal solar gain, as evidenced by sun-splashed rooms across the full width of the house's south side.

The kitchen, a streamlined command post, is the center of activity. Within visiting range of the dining room and earshot of the upstairs lounge, Doris can work in the kitchen and track the comings and goings of big and little people. European cabinets, expansive counterspace, and lots of storage remove clutter and simplify cleanup. The kitchen is handy to the foyer, utility, and garage so groceries or garbage needn't be toted far.

Hand-carved balusters of fir and larch follow the steps leading to the balcony-lounge which overlooks the airy dining space below. "When we overflow, I can stick kids up there," Doris said.

Around the corner from the kitchen, and a step down from the dining area, the living room is a comfortable retreat from the busier areas of the house. Its location past the dining room buffers the room from the chatter and bustle of the kitchen and loft, but without isolation.

Down the hall at the west end of the house, the Johnson's luxurious in-house getaway includes a large bedroom-

Owners
Gregg and Doris Johnson

Location
Huson

Designer
Scott Diettert
Drafting and Design, Inc
North 8605 Division
P.O. Box 18867
Spokane, WA 99208

Builder
Southwall Builders
644 South Second West
Missoula, MT 59807
549-7678

Style
1 1/2 Story with Partial Basement

Insulation
Ceiling - R60
2 x 6 Walls - R30
Crawlspace - R19
Basement Walls - R19
Slab - R5

Square Feet
Loft - 266
Main - 1,758
Basement - 1,146

Special Features
RSDP Construction

Heat
Electric Baseboard

Completed
November 1984

sitting room, bath, and oversized dressing room with its own sink and vanity. Cream-colored carpeting runs from master bedroom to the roomy bathroom. Here muted ivory- and red-striped wallpaper is a soft backdrop to the cheery red of the soaking tub and basin. Linking the master suite to a deck, French patio doors provide a view of the Clark Fork. A telescope stands ready to spot bighorn sheep as they scramble up and down the craggy cliffs on the far side of the river.

At the opposite end of the house, guest bedrooms and a full bath afford privacy to visitors. Two skylights in the north foyer shed abundant light on greenery in the hall planter. "However," Gregg noted, "the melting snow around those skylights shows we are losing some heat there."

Heat Averages Half That of a HUD House

The house's aesthetic performance is impressive, but how about its heating performance for 3,000 square feet? "Our highest monthly bill was $165," Gregg said, "and that included everything—cooking, lights, water pumping, hot water, and heat." According to the records he was required to keep for the RSDP program, space heating averaged 3.25 kilowatt-hours (kWh) per square foot annually, about half the average 6.58 kWh expected for a house built to HUD standards.

Construction Makes the Difference

The reasons for these low heating bills are hidden behind the home's tasteful decor. Blown-in cellulose insulates the spaces between the 2 x 6 studs framing the walls, and 1-inch Thermax sheathes the exterior beneath the siding. A thick layer of Silvawool insulates the ceiling. A 6-mil polyethylene air-vapor barrier was installed beneath the drywall and paneling in walls and ceiling. Fiberglass batts were applied to the inside of the basement and crawl space walls. On the outside of the walls and under the basement slab, 1-inch extruded polystyrene completes the thermal barrier.

Double-pane Clawson windows with low-E coating admit heat from the winter sun, and slow its exit after night falls.

The main living space is arranged across the south side of the house for optimum solar gain. On warm days, outdoor living is encouraged by French patio doors that connect dining room, balcony-lounge, and master suite to expansive decks.

Fit Overhang to Height

"We made one mistake when we redid the initial design of the house to incorporate raised-heel trusses," Gregg said. "We forgot to recalculate for their increased height, so the overhang isn't as long as it should be for the added roof height. The house tends to overheat in the summer, although if we cool it off at night, then close it up tight during the day, it rarely gets above 70 degrees in here."

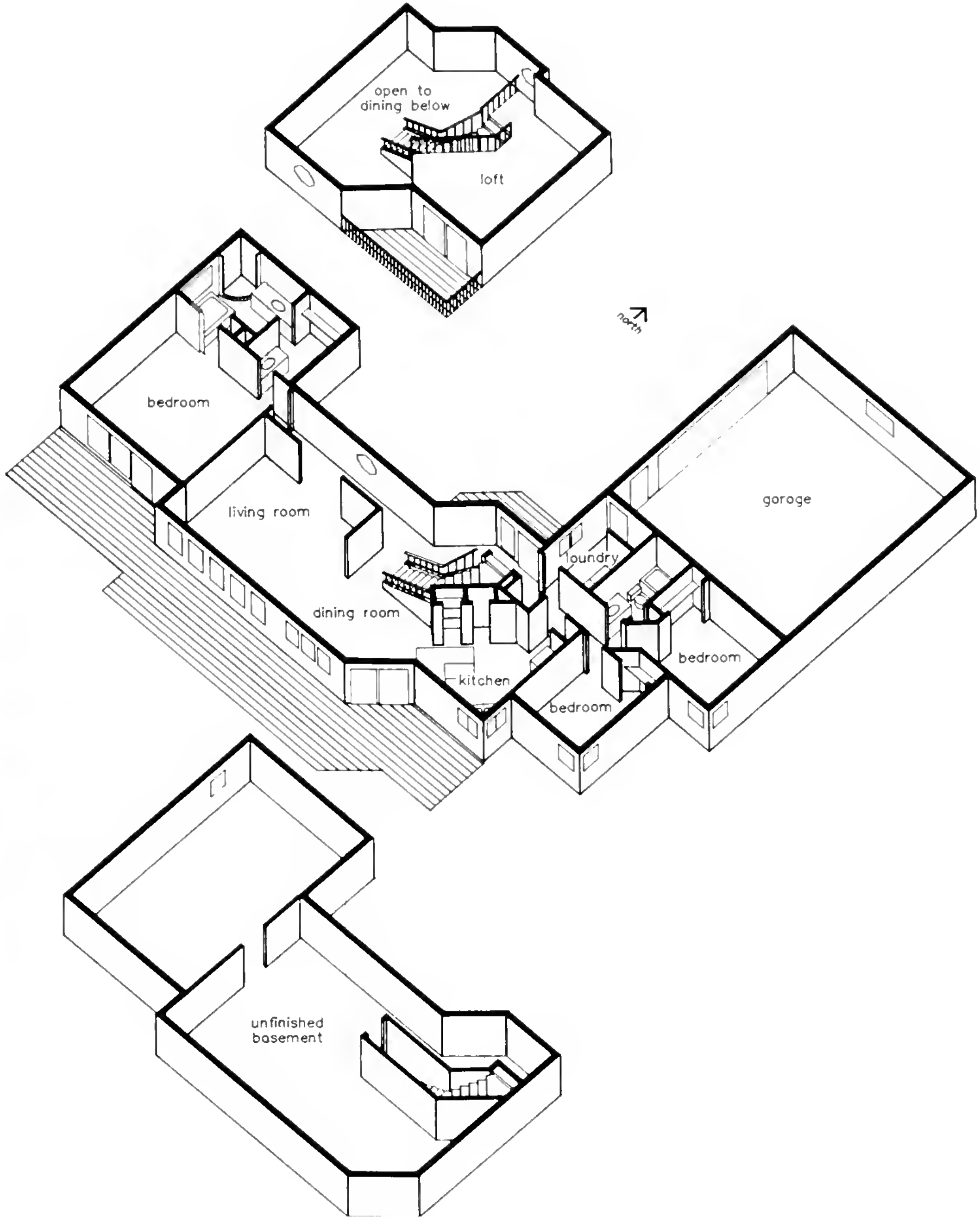
Heat Recovery Ventilator

The heat recovery ventilator has given the Johnsons some minor problems. "It freezes up when the temperature drops to around minus 10 outside," Gregg said. "When this happens, I have to take a section of the ductwork off and let it thaw—newer models have an automatic defrost." They turn the ventilator on manually for two to three hours a day. It turns on automatically when the humidity inside exceeds 40 percent. Gregg said sometimes in cold weather when the draperies have been shut overnight, their bedroom patio doors will have condensation in the corners.

Payback More Than Low Heat Bills

The costs for the energy-efficient construction added about $3.00 a square foot to the cost of the house. At the current rate of $0.05 per kWh, it will take about 15 years for the savings in heat to pay for the extra framing, insulation, glazing, air-vapor barrier, caulking, and heat recovery ventilator. But the Johnsons find the payback is more than a reduced heat bill. "It is comfort, clean air, and quality construction," Gregg said with a contented grin. ◻

North-facing glazing is limited to two octagonal windows, one in the loft (shown here), and one in the hallway, two skylights, and the narrow panes in the entry doors.



Hidden Quality Makes the Difference

Owners
Jim and Judy Andler

Location
Kalispell

Designer
Design Alliance
East 12504 Main
Spokane, WA 99216

Builder
Jim Andler
480 Batavia Lane
Kalispell, MT 59901
257-7905

Style
1 Story

Insulation
Ceiling - R65
Double Walls - R44
Floors - R30

Square Feet
2,100

Special Features
Sunspace
Window Treatment
Water Heater Timer

Heat
Electric Forced Air

Completed
June 1986

Outside, it was a cool 20 degrees. Inside, the unheated recreation room was too warm for a jacket. Jim Andler gestured to the cedar-paneled room. "My wife, Judy, and I opted for a rec room instead of a garage; I play drums with a local jazz band and needed somewhere to practice." Jim is also a builder and a crusader for energy-efficient houses. "Builders used to concentrate on finish carpentry for the aesthetic value; now what's hidden from view is just as important for the energy savings," Jim said.

Jim Andler

A sunspace provides a cozy retreat winter or summer for Jim and Judy Andler. Double-wall construction in the all-electric house keeps temperature extremes at bay and heating bills low.

Building Out The Cold

Jim explained the construction starting with the 14 1/2-inch-thick double walls which contain three layers of fiberglass batts. "I put in two R11 batts and one R19 batt. Behind the inner 2 x 4 wall stud wall component of the double wall, a 6-mil polyethylene air-vapor barrier stops air and moisture from moving into the walls from the living space. We caulked the poly at every seam, where wires penetrated, where plumbing entered, with Tremco acoustical sealant. We foamed the cracks between windows and frames," Jim said. Drywall covers all the walls, even under the wood paneling. "When you add the insulating value of the wood paneling, drywall, polyethylene, sheathing, Tyvek, and siding, the total R-value is around 44," he said. "The drywall under the paneling is for extra fire protection and to back the paneling."

Raised heel trusses provide room in the attic for a 24-inch layer of Insulsafe-III fiberglass insulation to the outside edge of each exterior wall. The floor over the crawl space is insulated with fiberglass batts. Latex paint seals the subflooring to minimize the amount of formaldehyde entering the air from the glue in the particle board. Jim said he was careful to use water-base paints, which don't contain formaldehyde, and was careful to select clear finishes with low formaldehyde content.

The wiring for each overhead light is contained in a shallow "pancake" box which fits snugly against the room side of the drywall and is more airtight than other electrical boxes. Only one double wire from the fixture penetrates the air-vapor barrier.

To prevent freezing of pipes, Jim isolated the plumbing from the exterior walls and crawl space.

Water Heater Setback Saves Money

In a closet in the airlock entry, Jim pointed out a blanketed electric hot water heater. "That heater is one of the most energy efficient, but what has really saved money is the Paragon setback timer. It comes on at 4:00 a.m. for 4 hours, then back on at 4:00 p.m. for another 4 hours. I really believe in having a timer on the water heater. It cost me $26 at the time and paid for itself in a matter of weeks." Kohler water-saving fixtures in the kitchen and bathrooms support the energy conservation effort.

Plenums Circulate Air

A heat recovery ventilator is mounted above the washer and dryer—out of the way, but easily accessible for filter changing. The ducts delivering fresh air to the house are encased in plenums.

The incoming fresh air flows free through the plenums while the outgoing exhaust air flows inside a 6-inch galvanized sheet metal duct in the center of the plenum. Every joint of the duct is taped to avoid mixing.

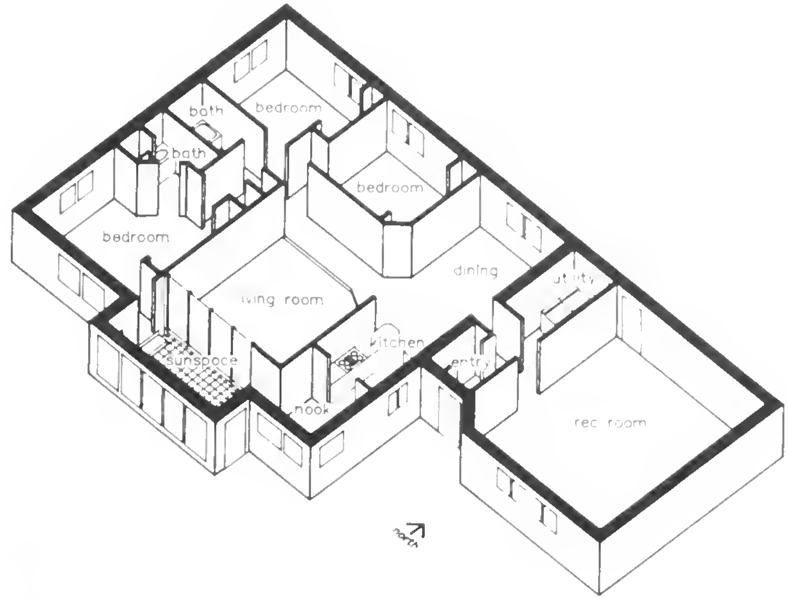
The Andlers run the ventilator continuously. At slow speed they get a complete air change every 2 1/2 hours. A defroster cycles periodically when the outside temperature drops below freezing.

"My wife has extreme sinus problems and the ventilator helps keep the dust and pollen out of the house," Jim said. "It also sucks up every bit of moisture. Steam doesn't even collect on the bathroom mirrors."

Window Treatments

Jim wrapped the window jambs with white formica and lined the sill with white ceramic tile. "The white reflects more light into the rooms, and the tile provides a wonderful base for plants," Jim said. "If condensation on the windows was a problem, the tile would prevent the moisture from damaging the sills. And the formica and tile weren't any more expensive than if I'd trimmed it with a veneer oak."

A Warm Window shade on the dining room window is the first of the set of insulated shades that Judy is making for all the windows. "We have double-glazed low-E windows," Jim said. "When this shade is pulled, the combined R-value of its fabric and the glazing is R11.6. The valance is backed with Velcro so it's easy to pull off and clean." Velcro at the shade's edges hooks to Velcro at the sides of the window casing to make a tight seal.



Light streaming through the sunspace's window wall highlights the rich knotty pine paneling of the living room. The warm ambience contrasts with the snow-covered fields outside.

Bringing in Light

The sunspace is accessible from the living room, master bedroom or outside. Its tiled floor soaks up heat from sunlight entering through the tall south-facing windows. A window in the kitchen looks into the sunspace and a glass wall transmits light from the sunspace to the living room. Frosted glass in the door to the bedroom from the sunspace protects privacy while letting in light. Cozy and warm on sunny winter days, the sunspace is comfortable in warm weather too. "The doors, window and skylights give us excellent ventilation," Jim said.

The Bottom Line

Before building, the Andlers took their plan to the Flathead Electric Cooperative. "Their computer projected average heating costs of $24 a month," Jim said. "We keep the house at 65 degrees during the day when Judy is teaching and I'm out building. In the evening we turn it up to 75 degrees, then set it back to 65 degrees when we go to bed." Their bills for the past year averaged $70 a month for cooking, hot water, lighting, and heating. Jim estimates that $30 of the $70 is for heating.

A Practical Design

"This is one of the most practical house plans I've ever seen, and it's affordable," Jim said. "Everything is on one level. My father-in-law recently told us we'd appreciate that more as we get older. In 1987 dollars I probably could build this house for \$40 to \$42 a square foot.

"In a real energy crunch, a person could easily install doors to close off different areas of the house. Since each room has its own heater and thermostat, you'd have the heat only where you needed it." He pointed out unobtrusive louvers covering a small heater in the wall. "These fan-forced electric heaters fit between the wall studs so you can put them anywhere, even in existing construction. I built this house with an eye to when we have real energy problems—when gasoline is \$10 a gallon." □

Aesthetics blend with energy-efficient features in the Andler house. Fabric covering the Warm Window shades harmonizes with the rose-beige carpeting. White formica protects the window jambs and reflects light into the dining room. The soffit running across the ceiling contains the duct for the heat recovery ventilator.

Quiet Comfort From Sunshine and Russian Furnace

Bruce and Yvonne McCallum's home outside Kalispell is testimony to their belief that energy-efficient housing is the only way to build. Its envelope design, solar heat, and Russian furnace keep it toasty warm on approximately 2 cords of wood per heating season. "It varies by only a few sticks of wood one way or the other each year," Bruce said.

In summer, the home cools itself. "When it's 100 degrees outside, the most it will get in the living room is 80 degrees," Bruce said. "Actually it's a combination superinsulated and buffered house. But the real beauty is that it has no fans, so it's quiet and peaceful."

Passive solar heating through the sunspace and envelope of Bruce and Yvonne McCallum's house means quiet comfort. The house faces 15 degrees west of south which is optimal for solar gain in Kalispell.

Envelope Plan Channels Heat

The home's envelope construction includes double walls on the north and south and a double ceiling, with space inside the walls and ceiling for air movement. The outer components of the north and south walls and the single thickness east and west walls are 2 x 6 studs with 5 1/2 inches of fiberglass insulation. The inner components of the north and south walls are 2 x 4 studs with 3 1/2 inches of fiberglass. The ceiling and roof insulation includes 12-inch fiberglass batts above the ceiling in the living space and 3-inch polyurethane beneath the shake roof above the air space for a total R-value of 50. All exterior windows are double glazed.

The concept of the envelope's function is that air warmed in the sunspace rises to the attic plenum, and then moves down through the inner wall space on the north side of the house, into the crawl space, and back up to the sunspace. The floor of the sunspace is made of 2 x 6 redwood boards spaced 1/4 inch apart, allowing air to enter from the 5-foot-deep crawl space below. In the summer, the house is cooled by a combination of vents on the north side and in the sunspace. Vents at the top of the sunspace allow hot air to escape, while ground-level vents on the north side of the house admit cool air to replace the escaping hot air. The drawings on the next page illustrate the airflow concept.

Because the house is buffered from outside temperatures by the envelope of warm air, it takes little heat to maintain a comfortable inside temperature. Much of the heat for the interior is gained through the door and single-pane windows separating the living area from the sunspace. Some heat from the warm air in the envelope is transmitted into the living space through the inner walls and floor.

Even though the Flathead Valley is overcast during much of the winter, the house receives solar gain on all but the most overcast days. "It's amazing to walk into the sunspace area on a grey day and feel the warmth through the windows," Bruce said. "If solar construction works

Owners
Bruce and Yvonne McCallum

Location
Kalispell

Designer
Positive Technologies
Box 2356
Olympic Valley, CA 95730

Builder
Al Hayner, Ron Rasmussen
Box 1657
Kalispell, MT 59901
752-2413

Style
Envelope

Insulation
Ceiling - R50
Double Walls - R39
Single Walls - R19
Crawl Space - R19

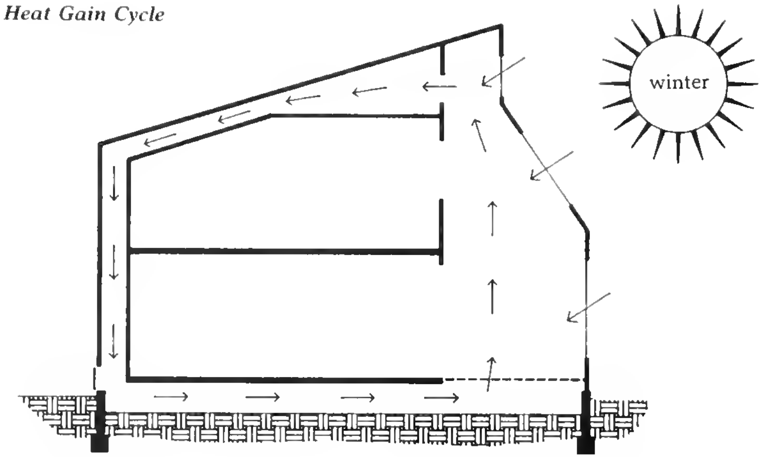
Square Feet
Upper - 766
Main - 1,184

Special Features
Envelope Construction
Sunspace
Russian Furnace
Earth Tube

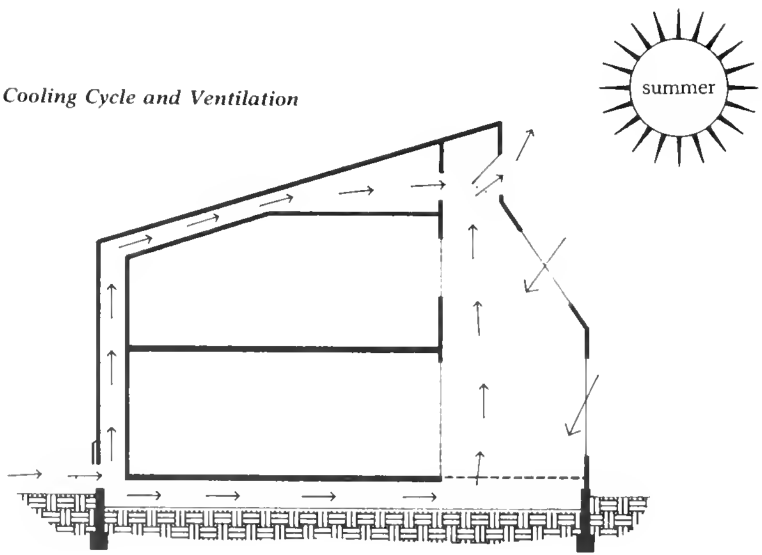
Heat
Passive Solar, Wood, Electric

Completed
November 1981

Heat Gain Cycle



Cooling Cycle and Ventilation



in the Flathead Valley, think how well it will work in the more sunny areas of Montana."

Sunspace More Than Heat

The sunspace does more than just harvest heat. "To us the sunspace is aesthetics, a hobby, and living space," Bruce said. "We love plants and spend a lot of time caring for them. Did you know that research shows plants reduce the amount of pollutants in homes?"

Sloped overhead glazing and big picture windows in the sunspace throw light to the farthest reaches of the home. Bruce said they don't use any artificial light during daylight hours. "If I had it to do over, I would make the south wall entirely vertical rather than sloping the second story," he said. "It would give us more space and the windows wouldn't drip. Until the wood surrounding the sloping windows swells and tightens, it leaks when it rains. But the drips don't cause any damage to the sunspace, so they're more annoying than a problem. One of these days I'll caulk them again."

Brick Furnace Stores Heat

The McCallums augment the sun's heat with their Russian furnace. "Anyone can build a Grubka, which is what this Russian furnace is called, if they have the time and are willing to read the instructions on how to do it," Bruce said. "I built mine for about $1,500 in materials, and estimate it has a 7- to 10-year payback. I also expect that the Grubka will far outlast energy-efficient gas or oil furnaces that cost about the same."

The McCallums burn one wheelbarrow load of wood every three days during the winter. They fire up the furnace in the morning before going to work and again in the evening. "Each time I put in a good armload and touch it off. It burns hot for about 45 minutes, then I shut it up tight," Bruce explained. "A sinuous flue carries the hot exhaust gas through the Grubka so that most of the heat is absorbed by the brick, later radiating into the living area and the sunspace. It's about 90 percent efficient.

"My wife was concerned about creosote buildup in the Grubka," he said. "But when we cleaned the 40-foot length of flue for the first time in five years, we got just about 3 quarts of soot from all the nooks and crannies. There was absolutely no creosote." The McCallums installed electric baseboard heaters as backup heat to comply with codes, but they never use them.

The McCallums also looped a water pipe through the furnace to preheat their domestic hot water. When the furnace is burning, water in the pipe is heated to 80 degrees before passing to the water heater, where it's heated to 120 degrees.

Earth Tube Brings in Fresh Air

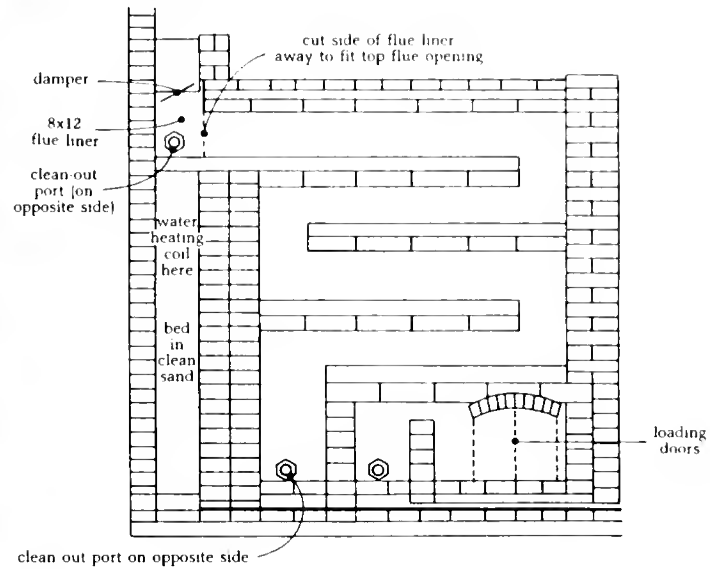
Fresh air enters the house through an earth tube that warms the cold air from outside. The intake end of the tube rises a foot above ground level east of the house, then extends 6 feet straight down. The tube bends several times for a total length of 85 feet at the 6-foot depth then rises 6 feet vertically to where it discharges in front of the air intake to the Grubka. "The air maintains a constant temperature of 53 degrees summer and winter," Bruce said.

Magazine Article Triggered Home Plan

How did they happen to build an envelope house? As Extension Agent for Flathead County, Bruce was well aware

The key to the Russian furnace's efficiency is its long serpentine flue. The brick absorbs heat as the hot air is forced to circulate through the furnace before exiting the chimney. In the McCallum house, the front of the furnace protrudes a foot into the living room and its back protrudes two feet into the sunspace to help keep plants warm on cold days when the sun doesn't shine. Bruce noted that for maximum efficiency, the furnace should be placed in the center of a house.

Russian Furnace Cross-section



that the future holds energy supply problems, and had been studying energy-efficient house design. "I built this home after seeing an article in the Co-Evolution Quarterly in 1978. The title was 'Don't Build a House Till You've Looked at This.' Later I saw an article in a popular magazine that showed the sunspace area in color. We fell in love with it, and ordered a copy of the plans. Although we moved the floor plan around while we were waiting for our other house to sell, we stayed with the original plan except for expanding in both directions," he said. "There were a lot of doubting Thomases when we began this home," Bruce mused. "The builder was skeptical because of the amount of material that went into the house. But it works; the whole principle works."

Plan Allows Flexibility

Bruce emphasized that envelope houses are just one type of conservation housing. "This is the best design for us, but people should be creative in designing a home for their needs. Other houses in the Flathead Valley have been based on this house but with changes. In Great Falls, my brother-in-law and sister built a modified envelope house that is earth sheltered. What is important is that people build conservation housing," he said. ◻

Affordable, Enjoyable, and Energy-efficient

Owners
Dixon and Mitzi Rice

Location
Kalispell

Designer
John Constenius
251 Elk Trail
Whitefish, MT 59937
862-4818

Builder
Phil Berger
319 Fourth Avenue East
Kalispell, MT 59901
755-4641

Style
1 1/2 Story with Basement

Insulation
Ceiling - R38
2 x 6 Walls - R19
Basement Walls - R19
Slab Perimeter - R15

Square Feet
Upper - 448
Main - 1,176
Basement - 1,176

Special Features
RSDP Construction
Outside Combustion

Heat
Air-to-air Electric Heat Pump

Completed
October 1984

Dixon and Mitzi Rice didn't think they could afford to build the energy-efficient house they wanted, so they took a long time looking at existing houses. "Finally we sat down and put all of our ideas from different houses into a plan and talked to Phil Berger who had been building energy-saving houses for years," Dixon said. "He worked with the architect to make our plan conform to RSDP standards and got us into the program. We have the house we want and it's fun to live in."

The handsome house looks out over the Flathead Valley from Summit Ridge subdivision, just north of Kalispell. Because of Kalispell's characteristically overcast winter days, the house wasn't designed for passive solar gain, though the builder oriented the living area with its large window wall to the south to capture any available rays. "It surprised us," Dixon said. "When the sun shines, the house really warms up. On Christmas Day, it got to 80 degrees in here. We had to open windows to get a cross-breeze to cool it off." The windows are Clawson Pine Craft double-glazed with low-E film. Dixon said they are effective heat traps. At night, insulated draperies help reduce heat flow to the outside. In summer, the roof overhang shields the interior from the hot sun.

From Summit Ridge subdivision in Kalispell, Dixon and Mitzi Rice's house looks south out over the Flathead Valley. The house is one of 67 built in Montana through Bonneville Power Administration's Residential Standards Demonstration Program.

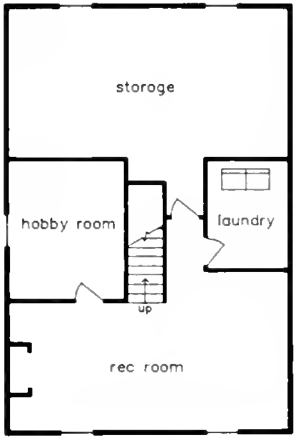
Efficient Heating

Heating and cooling is provided by a 40,000 Btu Carrier 38QF high efficiency air-to-air heat pump. The thermostat is left at a constant temperature. With an infant at home, the Rices keep the house at 72 degrees.

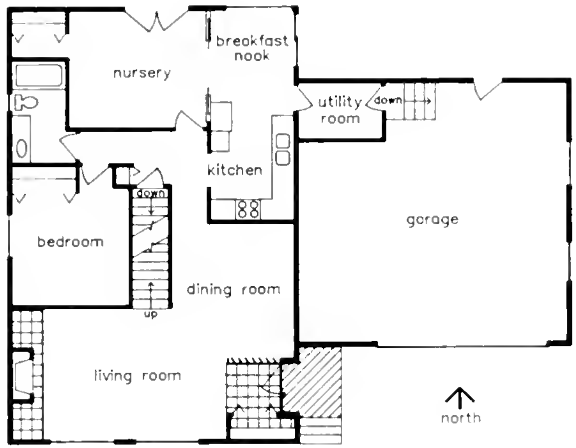
For the 1985-1986 heating season, the Rices used 12,652 kilowatt-hours (kWh) of electricity for space heating, approximately 5,800 kWh less than what a similar house built to HUD standards would use. The Rices attribute the savings to the extra-thick insulation and airtight envelope of the house.

Smart Construction

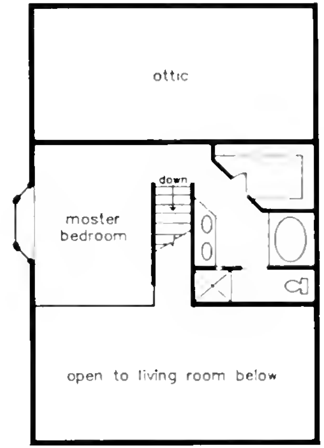
All walls in the house use 2 x 6 studs and 5 1/2-inch fiberglass batts, including the stud walls along the interior side of the 8-inch concrete basement walls. Two layers of 5 1/2-inch fiberglass batts insulate the ceiling. A continuous air-vapor barrier of 6-mil polyethylene restricts air and moisture movement from the inside. A rock base supports the foundation slab. The slab was installed over a 6-mil polyethylene moisture barrier. Between the moisture barrier and the rock, a continuous 2-foot-wide strip of 3-inch extruded polystyrene foam board insulates the perimeter of the slab. Foam inserts between the slab and the basement wall prevent thermal bridging.



BASEMENT



MAIN LEVEL



UPPER LEVEL

Dormer windows and a cathedral ceiling create an airy openness in the living room and bring in plenty of natural light.

Spun-bonded polyolefin seals the rim joists from air leaks.

An E-Z-Vent heat recovery ventilator brings fresh air to the dining area and nursery, and exhausts stale air from the two bathrooms and the kitchen. "We are very satisfied with the ventilator. It is so quiet, we rarely hear it running," Dixon said.

A raised hearth fireplace, paddle fan, and mahogany staircase accent the architectural elegance of the living room. The fireplace, Dixon said, is for atmosphere only. "We don't heat with it. The glass doors stop any heat from leaving the room by way of the chimney." Combustion air for the fireplace is piped directly from the outside into the firebox.

A dormer window brings light into the living room and master suite situated in the loft. A bay window on the bedroom's west wall lends its roomy sill to a collection of African violets. The deep color of the plants' tiny blossoms is repeated in the rose tones of the room's furnishings. Across the hall, a Velux skylight brings outdoor light into the spacious master bath and dressing room area, illuminating a cascading fern. Blue porcelain basins and rose-hued curtains further accent the color scheme of the house.

In the dining room tucked beneath the loft, wall mirrors visually extend the room's size and enhance its formal ambiance, making the room a fitting setting for candlelight dinners. Just steps away from the dining room, oak cabinets and almond-colored appliances impart a warm, cheery feeling to an L-shaped kitchen.

The tall windows of the sunny breakfast nook adjoining the kitchen provide a view to the patio and lawn. Besides being a bright spot for a morning cup of coffee, the breakfast nook affords entrance to other areas of the house. Sliding doors open into the nursery of the Rice's young son. From the nursery, a second door leads to the central hall. "This bedroom will become a den when our son is old enough for his own room in the basement," Dixon said. "That's why we planned for the circular traffic pattern."

The breakfast nook is also linked by French doors to a spacious outdoor deck a few steps up from the back yard. Insulated vertical shades and a valance stop convection currents from carrying heat out through the windows and patio door.

The basement is unfinished except for the laundry and mechanical room. Dixon said eventually the basement will accommodate two bedrooms, a recreation room and a hobby room.

The house was built for less than $70,000, excluding the lot. Approximately $5,000 of its cost can be attributed to energy-saving features such as the heat exchanger, air-vapor barrier, and extra framing, insulation, and caulking. This amount does not include the cost of the heat pump. For the Rices, however, energy savings is just a fraction of the picture. Dixon said an energy-efficient house is naturally well constructed and durable. □

Combustion air for the fireplace is piped directly from the outside into the firebox. Cinnamon-hued carpeting adds warmth to the traditionally styled furnishings in fabrics of cool blues and tawny beiges.

Practical House Uses Multiple Heat Sources

With four young children, Bob and Marria Ross set out to mesh practical living quarters with energy efficiency and affordability. "An earth-sheltered house seemed the way to go," Bob said, "but I wanted to be able to look out my windows without an earth berm in the way."

From experience, Bob knew how to build the house he wanted. He and his father have been constructing commercial and residential buildings in the Flathead Valley for more than 30 years. He put his experience to work, building his house in a meadow among timbered foothills south of Kalispell. Although he did most of the work himself in his spare time, Bob kept track of his materials and labor. He calculates that a similar house, not including the land or utility improvements, would cost about $100,000.

Earth bermed to the top of the shed roof shelters the west side of Bob and Marria Ross's house. The outside shed roof translates to an interior vaulted master bedroom ceiling. Sliding doors admit abundant light and provide a private route to the deck and a view of the surrounding meadows and woods.

Building for Northwest Montana

Bob tailored the home's shell for the reasonably mild winters of northwestern Montana and for wood and propane gas heat. The basement's concrete walls are insulated with 1 1/2-inch extruded polystyrene on the exterior down to 4 feet, with a 1-inch thickness continuing to the footings. The slab is not insulated.

Earth berming shelters the east side to just beneath the sills of the windows on the main floor, and shelters the west side to the second story. An insulated garage buffers the north side and acts as a vestibule entry.

Beneath the cedar siding, Tyvek covers 1/2-inch plywood sheathing over 2 x 6 insulated walls. Six-mil polyethylene, overlapped but not caulked, was installed beneath the drywall and paneling in the walls and ceiling. Above the areas with a flat ceiling, conventional trusses accommodate blown-in R38 fiberglass insulation. In the vaulted ceilings, 2 x 12 framing makes room for R38 fiberglass batts for insulation, and air baffles of extruded polystyrene for ventilation.

"The continuous soffit vents and a continuous ridge vent carry moisture out of the attic so the insulation can do its job," Bob said. Because the house is not airtight, the Rosses say they haven't needed a mechanical ventilator to control condensation or air quality.

Heating Takes Advantage of Trees and Sun

The Rosses were mindful of northwest Montana's plentiful stands of tall

Owners
Bob and Marria Ross

Location
Kalispell

Designer
John D. Bloodgood, AIA
2923 S.W. 30th Street
Des Moines, IA

Builder
Robert W. Ross Construction, Inc
P.O. Box 1121
Kalispell, MT 59901
257-5550

Style
1 3/4 Story with Basement

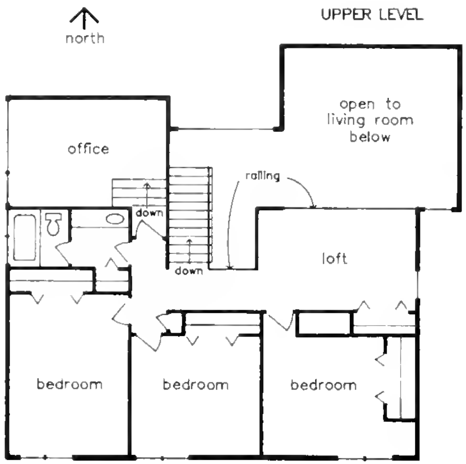
Insulation
Ceiling - R38
2 x 6 Wall - R19
Basement Wall - R8

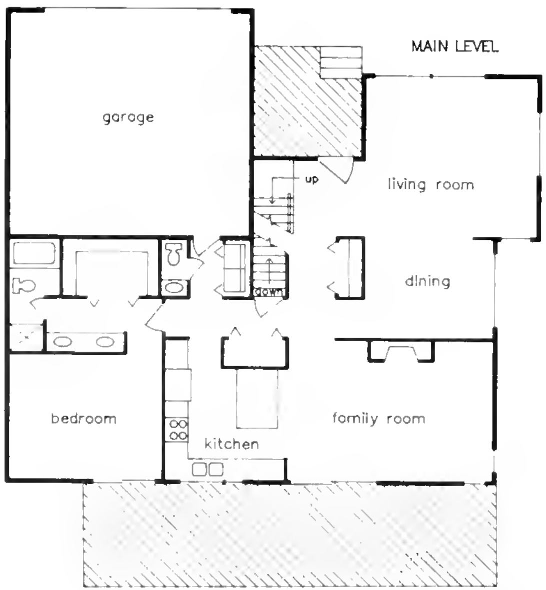
Square Feet
Loft - 1,200
Main - 1,400
Basement - 1,400

Special Features
Earth Berming
Thermal Storage
Outside Combustion Air

Heat
Propane, Passive Solar, Wood

Completed
January 1986





Berming to the underside of the windows protects the east (left) side of the house. The garage on the north shelters the entryway.

trees when designing their heating system. They chose wood as their main heating source, augmented with passive solar and propane.

A floor-to-ceiling fireplace with a Wood-Aire firebox was installed as part of the inside wall of the family room. "By putting the fireplace in the center of the house," Bob pointed out, "any heat absorbed by the rock is radiated to the rooms, not lost to the outside." Another source of wood heat is a large double-barrel wood stove in the basement.

Although cloudy skies predominate at Kalispell in the winter, the Rosses knew they could capture some heat from the sun on all but the darkest days. The fireplace stone absorbs heat from the sunlight entering the south-facing windows across the room.

For more thermal storage, Bob installed a reinforced concrete floor in the family room. The concrete absorbs heat from the sun and from the double-barrel stove in the basement below. Heat then radiates from the slab into the main floor living

The fireplace's central position provides even heat to the room and prevents heat from being lost through the rock to the outside. Thick, handsome quarry tile absorbs sunlight and stores heat.

area. "About the only thing I'd do differently," Bob said, "is to add more concrete for thermal storage."

When the Rosses don't feel like using wood they can use their Heil propane gas furnace. The condensing furnace is rated at 95-percent efficiency. "It was one of the earlier furnaces and didn't have a stainless steel heat exchanger," Bob said. "Propane gas has a lot of water in it, and the water and other byproducts in the condensation eventually corroded the unit. The manufacturer is replacing the heat exchanger."

To prevent the heating systems from consuming room air for combustion, outside air is piped directly to the firebox of the fireplace, and to the basement for the wood stove and propane furnace.

The Rosses keep their house at 64 degrees. "Because we have no drafts, we're comfortable with a cooler house," Bob said. For 1985, before the fireplace or wood stove were hooked up, the total heating expense for the Rosses was $300 for propane. In 1986, they burned four cords of wood they cut themselves, and about 25 gallons of propane. With four kids running in and out of the house all day and 4,000 square feet of heated space, Bob feels his heating bill is quite reasonable.

An earth berm on the east side of the house rises to a level just beneath the dining room window. The two-story-high ceiling opens the children's play area in the loft to the living room below.

Practical Plan

Good planning is evident in the house's floor plan. The center hall creates a free-flowing traffic pattern from garage or entry to all areas of the house. A washroom off the garage keeps little or big people from tracking in mud or snow. In the living room, the two-story-high ceiling forms a friendly, airy connection with the children's rooms and loft upstairs. "The kids can play in their rooms without feeling isolated from what's going on downstairs," Bob remarked.

All drywall is 5/8 inch. The paneling and wainscoting are tongue-and-groove fir and larch which is harder than cedar. "When you have four kids, you have to consider the beating the walls will take," Bob said.

All in all, the Rosses think their bermed design worked. "If I brought someone in here blindfolded, when the blindfold was removed, they wouldn't be able to tell this was a bermed house," Bob said. "We're also very pleased with the low heating bills and minimal maintenance." □

A Family Dream

Owners
Henry and Leona Barta

Location
Lewistown

Designer
Owners and Builders

Builders
Bud Barta
Route 2
Lewistown, MT 59457
538-8397
Rick Barta
5720 Homer Davis
Shepard, MT 59709
373-6753

Style
1 Story with Basement

Insulation
Ceiling - R60
Walls - R40
Basement Walls - R20 at top reducing in steps to R5 at bottom

Square Feet
Main - 1,250
Basement - 1,250

Special Features
Clerestory Windows
Superinsulation
Helical Staircase
Triple-pane Windows

Heat
Passive Solar, Natural Gas

Completed
June 1984

The new house of Henry and Leona Barta in Lewistown is based on "an idea dreamed up by the family," according to the Bartas' son Bud, who built the house along with his brother Rick. A large part of the planning had to do with energy efficiency. The idea seems to have been a good one. So far, the biggest annual heat bill for the 2,500 square feet of living space (including the finished basement) has been $260. For February 1987, for example, the bill was $25.

The Barta house in Lewistown is cheap to heat and never needs painting.

Superinsulation Makes it Happen

Bud and Rick made low energy bills possible by using superinsulation construction methods. Both Barta brothers are house building contractors, specializing in superinsulation. On their parents' house, they used double 2 x 4 walls with R40 fiberglass insulation. They installed a 6-mil polyethylene air-vapor barrier on the back side of the innermost stud wall. All windows are Pella triple pane.

The Barta house is not only energy efficient but also a highly liveable and painstakingly individualized residence. Bud has shown the house as an example to clients who said they didn't want superinsulation in their houses, and after a tour, they changed their minds. "Everybody just loves it," said Leona Barta.

Scissors Trusses Enlarge Space

The use of scissors trusses produced a living room ceiling with a cathedral effect that adds to the feeling of spaciousness. Fifteen inches of blown-in fiberglass brings insulation value in the ceiling to R60. Bud Barta likes to design houses with clerestory windows and skylights to bring natural light to the interior, and this house is generously equipped with these features. A 5-foot-square, triple-thickness skylight floods light into the stairwell where the hand-made helical staircase descends to the basement. This staircase turns around an atrium on the basement level, where tall plants get the benefit of light from the skylight. Large, south-facing windows on the main floor let sunlight in to brighten the interior and provide passive solar heating.

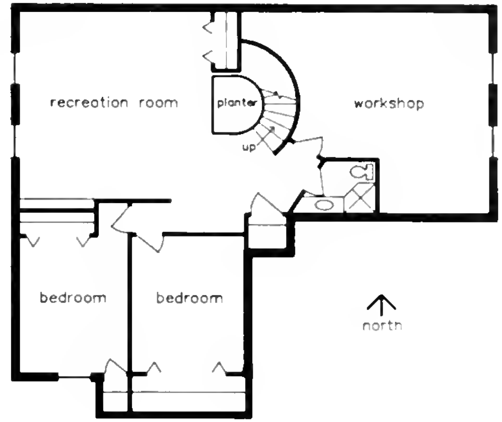
The ceiling in the master bedroom and bathroom sweeps up to 17 feet on the south side, and four clerestory windows along the top of the south wall bring a pleasant level of natural light to this part of the house. The only source of heat other than the sun for this house is a Dyna-Fine 30,000 Btu natural gas furnace that fits between two joists in the floor of the main level. Bud said this system is slightly undersized for the house, and if he had it to do over he would use a hydronic coil connected to a natural gas-fired hot water heater to heat the house. The existing furnace can be used to cool the house on hot summer days simply by starting up the furnace fan which brings cool air from the basement up to the main floor.

A Buried Ventilator Pipe

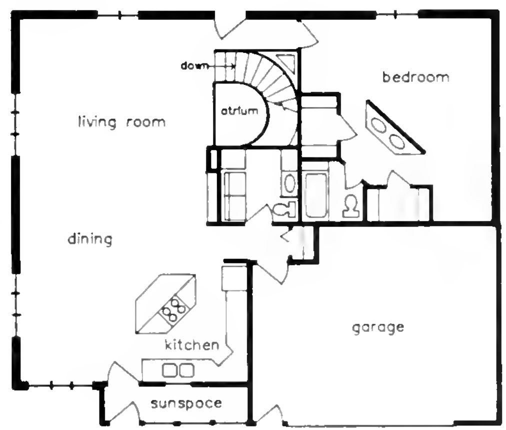
As usual with superinsulated houses, a heat recovery ventilator is necessary to maintain indoor air quality. Intake air for

A custom touch is provided by the helical staircase and basement-level atrium with overhead skylight.

BASEMENT



MAIN LEVEL



the ventilator is brought through a pipe buried below the frost level, which tempers inflow air year-round. This reduces the amount of heating the air needs in the winter.

Nothing to Paint

The Bartas chose steel siding for their house, which leaves them to decide what to do with the time and money they otherwise might have spent painting. "There's nothing on the outside that's ever going to need painting," Bud said. The Barta's used steel roofing of an unconventional type designed to look like red Spanish roof tiles. This illusion is maintained even upon examination from a few feet away. "That was the most expensive steel roofing available," Bud said.

Bud said this house required about $65,000 in material, and he estimated that he would charge about $90,000 ($36 per square foot) to build a similar place for a client. □

Scissors trusses make the spacious living room seem larger.

A Well-lighted House

Winter gloom is not likely to visit the new house built for Charles and Sally Karinen on their sheep ranch east of Lewistown. Besides the extensive array of glass on the main level south side of this superinsulated structure, a row of clerestory windows brings natural light to the upper level of the house. This brightens the upstairs loft, including a bathroom on the north side. The bathroom has a translucent ceiling to admit the light that comes through the clerestory windows and reflects down from the ceiling. A roof overhang above the clerestory windows serves the double purpose of keeping direct sunlight out in the summer and reflecting low-angle sunlight into the windows in winter. A built-in greenhouse provides heat for the living space on sunny days. All windows are Pella triple pane.

The Karinen house has three levels, with 1,208 square feet on the main floor, 900 square feet upstairs, and 672 in the half basement. The greenhouse is 22 x 8 feet.

Native Montana Wood Products

The builder of the house, Bud Barta of Lewistown, said he used native Montana wood products in the house when they were available. The main level is floored with fir, except the kitchen. The vaulted ceiling is tongue-and-groove pine.

Exterior walls, made with two 2 x 4 stud walls set 5 1/2 inches apart, are more than a foot thick, and filled with insulation. Each component stud wall is insulated with 3 1/2-inch fiberglass batts between studs, and the space between the two wall components is filled with horizontal 5 1/2-inch fiberglass batts. The three thicknesses of batts in the walls have a combined value of about R41. The 14.5 inches of fiberglass batts in the vaulted ceiling insulate to about R49. The continuous air-vapor barrier is provided with the advanced drywall approach (see Glossary).

The Karinen house is designed to let in the sun.

Electric Furnace for Heat

The Karinens use an air-tight wood-burning Kozy-Heat circulating fireplace as their main source of heat beyond what they get from the sun. On cool mornings, the Karinens build a fire first thing, which quickly heats the house. On sunny days when it is not extremely cold outside, the sun takes over the heating load as the day warms. The greenhouse space sometimes drops below freezing on cold nights, so the door between the greenhouse and the living room is kept closed except during cool, sunny days, when it is opened to let sun-warmed air into the house.

Solar and wood heat are backed up with an 11 kW electric furnace that operates in series with the Vent-Aire heat-recovery ventilator, and uses the

Owners
Charles and Sally Karinen

Location
East of Lewistown

Designer
Owners and Builder

Builder
Bud Barta
Barta Construction
Route 2
Lewistown, MT 59457
538-8397

Style
2 Story with Partial Basement

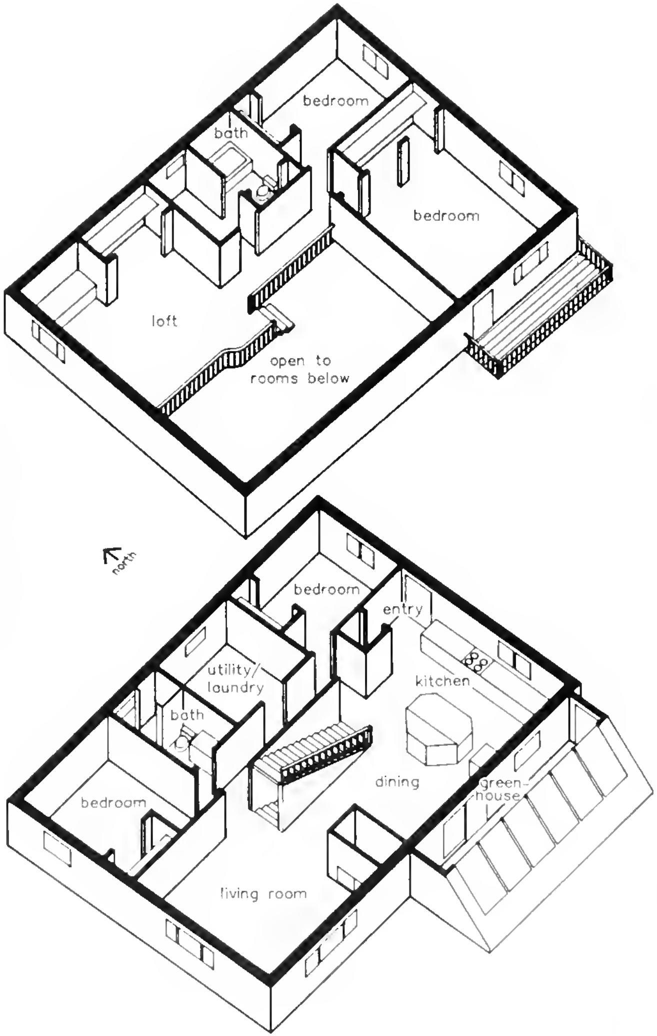
Insulation
Ceiling - R49
Walls - R41

Square Feet
Loft - 900
Main - 1,208
Basement - 672

Special Features
Heat Recovery Ventilator with Buried Intake Pipe
Clerestory Windows
Greenhouse

Heat
Passive Solar, Wood, Electric Furnace

Completed
April 1987



Clerestory windows bring light to the upper level.

same ducting. Barta said that if natural gas had been available, a hydronic coil from the domestic hot water heater could have been installed in place of the electric furnace, and that this would have provided more economical heat. The furnace operates in conjunction with an electrostatic air filter that cleans smoke, pollen, and dust from the air before the furnace fan blows it back into the living space.

Charles Karinen said he and Sally do not particularly like the furnace because of its noise. "Just when you're trying to get to sleep, the furnace blower comes on," he said, adding that the furnace is good for keeping the house from freezing up when they are gone. Otherwise, they don't use it much, relying on the wood instead. Charles estimated that they burned 2 cords of wood to heat the house over the winter.

An Underground Air Pipe

Intake air for the ventilator is drawn through an 8-inch corrugated pipe that is buried below the frost line with an intake above ground level. (DNRC building specialists suggest that a smooth pipe is better for this purpose. Corrugations hinder the flow of air through the pipe.) The earth warms the intake air to well above freezing year-round. The bottom of the pipe is perforated to drain condensation into the gravel bed under the pipe.

A Testimonial for Superinsulation

Charles said his family's first winter in his new house had made him a believer in superinsulation. "I wasn't sure about superinsulation at first," he said. "I saw some superinsulated houses with little windows, and I thought, 'Boy, this is going to be like living in a breadbox.' " The Karinens wanted their house to resemble a breadbox as little as possible, so they had Bud put in more windows than he wanted to, Charles said, adding, "We like a little light." Now they have both light and warmth, proving that superinsulated houses need not be breadboxes with tiny windows.

Part of the Karinens' satisfaction with their new house stems from the contrast with their old house, which Charles said was drafty as an old barn. "You could see the curtains move when the wind was blowing," he said. Although the Karinens are pleased with their new house, they have a few thoughts about possible improvements. For example, Charles said, it might be nice to have more ceiling fans than the one they have at present to recirculate heat from the ceiling back down to the main level. The open design with a loft leaves the warm air free to rise to the cathedral ceiling. Also, Charles said, if he had it to do over, he would investigate the economics of installing a propane heating system rather than the electric furnace.

Custom Features Raise Price

Bud said the cost to build the house was between $90,000 and $95,000, or about $42 per square foot. He said costs were driven up in part by the substantial amount of custom work the owners wanted. For example, considerable time was spent building a hand-made railing for the stairs and along the edge of the loft floor. This railing has 15 layers of contrasting wood laminated into a single eye-catching piece. Such custom details, along with the modern energy-efficiency design and construction, ensure that the Karinen house will never be mistaken for a breadbox. □

Tricks for Saving Energy

Owners
Douglas and Cindy Hardy

Location
Livingston

Designer
Owner

Builder
Albert Osen and Sons
Big Timber, MT 59047
932-4281

Style
1 Story

Insulation
Ceiling - R45
Double Walls - R38
Crawl Space Walls - R19
Floor - R19

Square Feet
2,800

Special Features
Brick Walls
Triple-glaze Low-E Windows
Heat Recovery Ventilator
Heating Coil Off Water Heater

Heat
Passive Solar, Electric Baseboard
Heating Coil in Ventilator

Completed
June 1985

Through his job as an energy auditor for the Park Electric Cooperative in Livingston, Douglas Hardy has learned all the tricks for conserving energy in houses, and he used most of them when he had his own house built on the bank of the Yellowstone River just east of town. Even with a new baby requiring 75 degree temperatures, it only cost Douglas and his wife $324.50 to heat the house's 2,800 square feet during their first year of residence, from June, 1985, through June, 1986.

The garage at the southwest corner of the Hardy house helps deflect prevailing winds.

Starting with Basics

To get his bills this low, Douglas started out with a basic superinsulation design and modified it to provide greater energy savings. The thick exterior walls are built with two 2 x 4 stud walls set 2 inches apart. Spaces between studs are filled with 3 1/2-inch R11 fiberglass batts. The 2-inch space between the stud-wall components is filled with an R16 thickness of polyisocyanurate foam board. A polyethylene air-vapor barrier was placed between the foam board and the inner stud wall. (DNRC building specialists suggest that the polyethylene air-vapor barrier probably was not necessary, because polyisocyanurate boards make an adequate air-vapor barrier when the seams between them are taped together.) R-value of insulation in the exterior walls is about R38. The ceiling is insulated with 1 inch of sprayed-in-place urethane foam (R7) above the drywall, with 12 inches (R38) of blown-in wood-fiber cellulose above that.

Bricks Instead of Cedar

Perhaps the major deviation from the usual practice with superinsulated houses was the use of brick walls rather than conventional siding on the outside of the house. Douglas said the cost of purchasing and installing the brick was only about $1,500 more than the cedar siding he originally intended to use. The durability and low maintenance of brick give it a decided advantage over most types of siding. A ventilation air space of about 1/2 inch was left between the brick wall and the outer stud wall. This space is open to the soffit vents. Owing to the impermeability of the air-vapor barrier, no condensation is expected to occur inside the exterior walls, and no weep holes were installed in the brick walls. There are no utility penetrations of the brick wall. Windows are triple pane, low-E Weather Shield casement.

Crawl Space Saves Money

This house has a 4-foot crawl space rather than a basement. The crawl space walls are insulated with 2-inch expanded polystyrene boards sealed to the concrete with foamed-in urethane. The seams where the polystyrene boards join are covered with spray-on urethane foam. Over this polystyrene, 3 1/2-inch fiberglass batts were installed. Two inches of urethane insulates the rim joist. The floor above the crawl space is insulated with R19 fiberglass batts. A polyethylene moisture barrier on the ground at the bottom of the crawl space prevents entry of dampness from the earth below.

Indoor air quality is maintained with a VanEE heat recovery ventilator. Coils added to this system provide heating and cooling. In winter, a small pump circulates 140-degree water from the water heater through the heating coil in the

ventilator. This coil warms the air coming in through the ventilator. On one occasion when it was 20 below outside, Douglas measured the temperature of the air warmed by this coil and found it to be 85 degrees. A second coil is equipped with a fan to provide heat directly to the living space. Douglas said these two coils produce about 5,000 Btu each. In the mild winter of 1987-88, the two coils produced all the heat necessary to warm the house, Douglas said. Electric baseboard heaters are in place to provide additional heat if necessary.

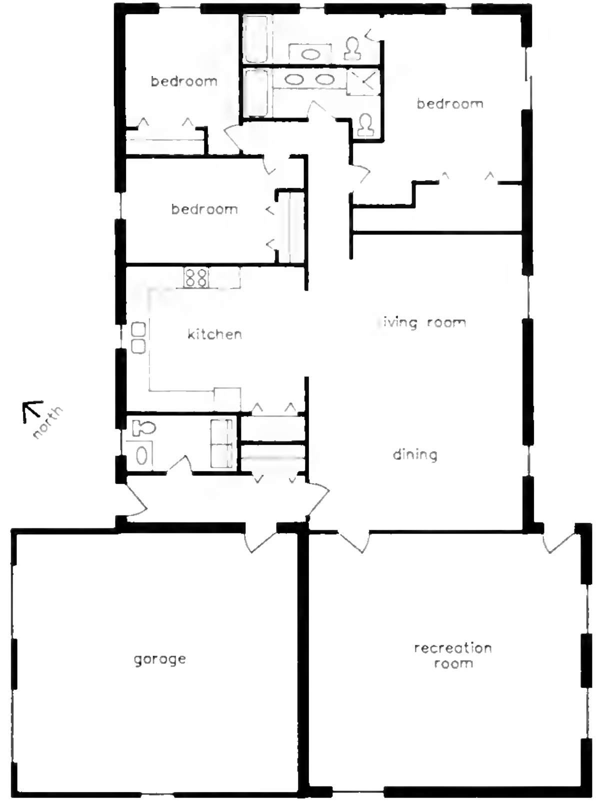
In hot weather, a valve is opened to run water from the well through the cooling coil in the ventilator. This cools the incoming fresh air. The water is then pumped outside to water the lawn.

Innovative Design Deflects Wind

The Hardy house is configured in two rectangles, one 52 x 40 feet, and the other 26 x 56. The smaller rectangle contains the two-car garage and is on the upwind side of the structure where it helps deflect the wind from the living space. Orientation in relation to the wind is especially important in the Livingston area because of the unusually powerful and persistent winds. Entrances to the house are placed in the sheltered areas around the corners of the garage, which prevents the wind from entering when doors are opened.

Economy Measures Pay Off

Douglas designed his house to save money not only on energy use, but also in construction costs. One part of his money-saving strategy was the use of a crawl space rather than a basement, which would have cost substantially more. Another economy measure was the use of Optimal Value Engineering (OVE). OVE includes the practice of designing structures with dimensions in multiples of 4 feet. This makes it possible to use building materials that come in 4 foot sheets (such as drywall and plywood sheathing) with little need for wasteful trimming. Doug said only about one pickup truck load of waste was generated during installation of his drywall, compared to the three loads that normally result from a project this size.



The crawl space in the Hardy house is insulated with expanded polystyrene on the concrete walls, with fiberglass batts over the polystyrene. A moisture barrier keeps dampness out. Floor overhead is insulated to R19.

The Hardys kept the price of their house to about \$84,000 (\$30 per square foot), partly by doing some work, such as wiring, insulating and plumbing, themselves. Doug said most of the energy-efficiency measures should pay back in five years or less. He estimated it would cost about \$35 per square foot (\$98,000 total) to have a contractor build a similar house.

Some Modest Improvements

The Hardys are pleased with their new house, but said if they had it to do over, they would make some rooms larger. The laundry room, for example, they would make 12 x 5 rather than 9 x 5. They would enlarge their present 7 x 13 bathroom to 8 x 14. Also, they would consider insulating the baby's bedroom so it could be kept warmer than the rest of the house. Otherwise, the tendency of superinsulated houses to stay at a uniform temperature throughout makes it necessary to heat the whole house to the temperature the baby needs. □

Workshop Points the Way

Owners
Calvin and Donna Stenseth

Location
Lolo

Designer
Owners

Builder
Roger Fangsrud
706 Gary Drive
Missoula, MT 59801
549-5484

Style
1 Story

Insulation
Ceiling - R40
Double Wall - R41
Crawl Space - R19

Square Feet
Main - 1,478

Special Features
RSDP Construction

Heat
Electric Baseboard

Completed
October 1984

Donna and Calvin Stenseth had been living in a trailer for 20 years when they decided it was time to change living quarters. "In the winter, the baseboards of the trailer would frost over and sometimes the walls. Then black mold would form. If we laid something against the wall, it would stick to it," Donna said. "We wanted something warm."

Looking for A Builder

The Stenseths had their house plans picked out and were looking for a builder when they attended a workshop for new home buyers. The workshop, sponsored by the Montana DNRC and Missoula Electric Cooperative, explained the benefits and construction of an energy-efficient house. "That seemed to be the ticket," Donna said.

"After the workshop, we talked to four or five different contractors who were plainly not interested in building an energy-efficient house. Then we met Roger Fangsrud. He was building energy-efficient houses, and knew about the Residential Standards Demonstration Program and submitted our house for it. We can't say enough nice things about Roger."

RSDP Extras

The Stenseth house sits part way up a hill in the Lolo Pass, a little more than 3 1/2 miles from the town of Lolo. A sign in front identifies it as an RSDP house.

A minor problem for Calvin and Donna has been the public's misconception of the RSDP. "People are under the impression that we haven't paid a nickel for this house," Donna said. "We have to continually explain that the RSDP only paid for certain items that exceeded HUD building standards, to find out how cost-effective they are."

Some of these items are extra framing and insulation, a continuous air-vapor barrier, and a heat recovery ventilator. The Stenseth house has double 2 x 4 walls with a 6 1/2-inch space between inner and outer walls. The deep walls allow room for three layers of fiberglass batts. In the space between the walls, the fiberglass batts are placed horizontally and supported by twine ties to keep them from sagging. The walls are insulated to a total R-value of 41. The ceiling holds 24 inches of blown-in cellulose. A continuous 6-mil polyethylene air-vapor barrier was installed behind the interior 2 x 4 wall and in the ceiling. Every seam was caulked with Tremco sealant. The crawl space walls are insulated with fiberglass batts, and a 6-mil polyethylene moisture barrier was placed over its dirt floor. Tyvek wraps the rim joists and is sealed to the air-vapor barrier. A heat reflective low-E film coats the double-glazed Clawson windows and sliding patio door.

"A lot of people have asked us if we feel closed in because of our deep

Calvin and Donna Stenseth's house has a 5-foot overhang to shield the living room window and the porch from the hot rays of summer sun.

walls," Donna said. "I point out that it's no different than a log house. Besides," she added, "it gives us a sense of security—there's more between us and the elements."

Resolving Ventilator Problems

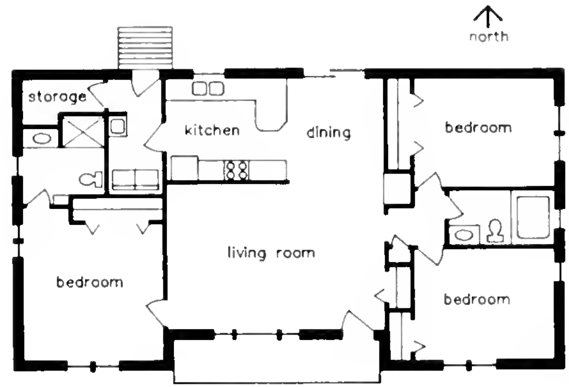
The Stenseths had some trouble with their heat recovery ventilator. Air whistled through it so fast that the draft blew out candles, and the speed didn't allow much heat to be exchanged between outgoing and incoming air. "For months we had 42 degree air coming in," Donna said. "We were wearing long underwear and were still freezing." The house was full of dust and there was condensation on the windows.

Calvin said that Bob Touse at Missoula Electric Cooperative worked closely with them, as did Heber Miller, the electrician, who discovered the problem was a faulty dehumidistat that read 15 degrees high. This meant the ventilator worked at high speed any time the inside humidity exceeded 30 percent—which was all the time. As soon as the faulty control was replaced, the ventilator worked fine. Calvin laughed. "The reason we had such a warm winter that year was because I was heating the outdoors."

Now the exchanger runs for 15 minutes every 2 hours, and the temperature of the incoming fresh air is between 52 and 55 degrees. The inside humidity level stays at 45 percent. The dust has disappeared and the windows have no condensation. Maintenance of the ventilator consists of balancing the dehumidistat with the weather and cleaning the filters.

About the only changes the Stenseths would make is to add another air distribution vent in a front bedroom. If the door is closed, the room gets quite stuffy.

Deep windowsills on the living room window evidence the thick insulated walls that buffer the Stenseth's living quarters from weather extremes.



Construction Paying Off

The Stenseths discovered that the added insulation and air-vapor barrier are indeed cost-effective. They averaged 5,700 kilowatt-hours (kWh) annually for space heating ($257 at 4 1/2 cents per kWh) compared to the average 13,300 kWh ($599) used by a house of the same size built to HUD standards. "When I talk to people who don't have energy-efficient houses," Calvin said, "I realize our total electric bill is terribly cheap. They can't believe we're getting off so light."

They certainly get off lighter than they did in their old mobile home where the annual electricity bill averaged $1,080, besides the cost and mess of operating their wood stove, which they are glad not to have in the new house. "Can you imagine what a wood stove would do to these light colored walls?" Donna said. "I'd be washing them all the time." Calvin said that although they periodically miss the hot spot of a wood stove, it's nice not to have the stress and strain of gathering their winter's wood supply.

Although their living room faces south, solar gain is limited because of the high cliffs surrounding them. "We don't get much direct sun until about March," Calvin said.

Squeezing Pennies

Cost was a major consideration for the Stenseths, which meant careful placement of rooms in the limited floor space. The master bedroom is sequestered from the teen bedrooms and the inherently active kitchen-dining area. Minimal floor space has been allocated to hallways. On the north side of the house, an entrance from the covered patio to the kitchen cuts down on dirt and snow tracked onto carpeting.

"We worked hard to keep the cost of the house down," Donna said. "We managed to find quality oak cabinets on sale. We used hemlock molding and stained it to match the oak."

Calvin said that the house fulfills their dream of a warm place to live. "It has absolutely no drafts and no air stratification. It's a very even heat, very comfortable, and very clean." □

Architectural Elegance Meshes with Energy Savings

Owners
Bob and Ferna Geer

Location
Manhattan

Designer and Builder
David Andreassi
P.O Box 372
Manhattan, MT 59741
284-6650

Style
1 3/4 Story

Insulation
Ceiling - R60
Double Wall - R45
Crawl Space - R19

Square Feet
Upper - 650
Main - 1,600

Special Features
Windows
Sunspace

Heat
Passive Solar, Electric Baseboard

Completed
November 1986

Anyone shopping for a house knows there are plenty to choose from. However, as Ferna and Bob Geer found, quality isn't always part of the package. "We looked at a lot of houses," Ferna said. "There were just too many construction shortcuts in most of them, and the amount of repair needed was atrocious." The house the Geers finally chose was head and shoulders above most of the others they examined. "This house had it all—a floor plan we liked, a builder with a reputation for backing up his work, and energy efficiency. We especially liked the use of river rock and redwood on the exterior," she said.

An antique crank door ringer at the front door hints at the builder's attention to detail. The inside radiates a country charm with its print wallpaper, wainscoting, and natural wood flooring in the front hall, guest bath, dining room, and kitchen. One step up from the dining room a landing leads to the back door and provides a parking spot for snow boots and overshoes, wool jackets, snowsuits, and mittens. In the living room, cinnamon-toned carpeting and ivory walls enhance the rich grain of mahogany and oak in cabinets, woodwork, and flooring.

A six-sided tower dominates the north side of the house. The tower houses the nursery upstairs and a utility room below. Across from the nursery, south-facing dormer windows channel heat and light into the master bedroom. "We haven't had the heaters on upstairs since we moved in," Ferna said, "plenty of heat

The open setting of Bob and Ferna Geer's house in the quiet village of Manhattan allows for significant solar heating in the winter.

rises from downstairs to the kids' room and the bath.

"This house is so different from the mobile home we lived in for twelve years. There I had to get up and turn on the heat in the morning before anyone would get out of bed. Here the temperature stays pretty constant—not much change from evening to morning. And in the summer this house is cool during a hot day, yet retains warmth on cool, rainy days."

Windows Trap Heat

The triangular and trapezoidal windows in the living room are triple-glazed with low-E film to trap heat indoors. Heat loss through the rectangular windows is slowed by double glazing augmented by insulated Window Quilt shades. Ferna said she is careful to use the shades correctly, rolling them down on chilly winter nights and hot summer days.

Just off the living room, a long, narrow, glassed-in alcove acts as a mini-sunspace, collecting heat and serving as a cozy play spot for the Geer's two young children.

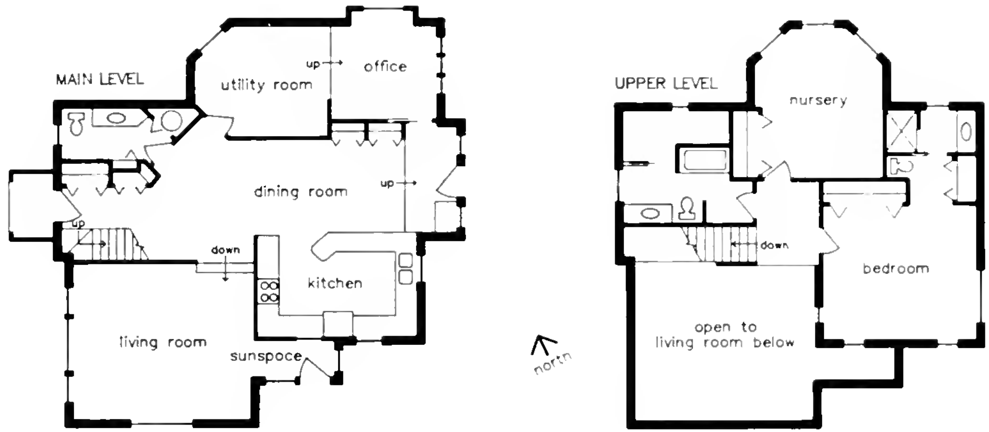
Electricity Augments Solar

Although Bob is a logging contractor, the Geers chose not to have a wood stove. "Bob lives in the woods for a good part of the year and gets enough of chopping and

hauling wood there. He doesn't want to mess with it when he's home," Ferna said.

Electric baseboards augment the solar heat. During the day, the house is kept at a comfortable 69 degrees for the children, and is turned down to 60 degrees at bedtime.

Two submeters let the Geers track the kilowatts used for hot water and space heat. "Our electrical usage since we've moved in has been about one-third heat and one-sixth hot water," Ferna said. "Our January bill of $145.50 was the highest. This included everything, even a hot tub and heat for a weight-lifting room in the garage. Our monthly electric bills during the summer have been a little over $50." She added that their teenager's long showers and an old refrigerator drive up the bill.



A large deck at the back of the house provides a spot for fair weather relaxing. The small windows in the tower on the north minimize heat loss.

Keeping Humidity in Balance

The Geers normally keep the inside humidity at 60 percent. "Because of all the wood in this house, we need some humidity," Ferna said. But, to prevent condensation on the windows in winter, when the outside temperature drops below zero, the Geers adjust the dehumidistat so the heat recovery ventilator will turn on when the inside humidity rises to 40 percent. But just in case, the windowsills have a water sealer coating on them to prevent staining of the woodwork. Ferna said that during the summer they often shut off the ventilator and open the windows. "Except when it's windy," she added, "then I close the windows and use the ventilator; it really keeps out the dust. It also gets rid of cooking odors."

A Satisfying House

Would they do anything different? "No!" replied Ferna The house is so self-sufficient, we can't think of a thing that would improve it."

David Andreassi, the builder, said the extras for energy efficiency cost about $7,500. These extras include the Window Quilts, extra lumber and insulation in the walls and ceiling, the air-vapor barrier, window glazing, and the heat recovery ventilator. Dave said building a similar house in 1987 would cost approximately $45 per square foot, not including the lot and improvements. "As far as payback on the energy costs, it's fairly long term, unless we have an increase in utility rates. But, there's more to it than that," he added "These houses keep their value because of their quality, and they are comfortable." He said that he'd been

building houses for over 10 years, and was convinced a number of years ago that energy-efficient houses were the way of the future.

Careful construction helps maintain the low bills and even temperature in the Geer house.

- double 2 x 4 walls filled with fiberglass blown-in batts (BIBS)
- a ceiling packed with BIBS in the flat portion and urethane foam in the vaulted portion
- a 6-mil polyethylene air-vapor barrier tightly caulked at all seams
- fiberglass 6-inch batts in the floor joists
- 2-inch foam board on the exterior of the crawl space walls
- insulated 1 3/4-inch-thick steel exterior doors
- urethane foam sealing windows, doors, rim joists and box joists, and where all electrical and plumbing connections penetrate to outside
- minimum number of ceiling fixtures penetrating the air-vapor barrier
- a ceiling fan which continuously circulates the air
- a VanEE-2000 heat recovery ventilator. □

A window over the kitchen sink provides a view into the sunspace and to the outside. The countertop divides the kitchen from the dining room, offering space for food preparation and quick meals.

Windows open the living room to sunlight and emphasize the sweep of the vaulted ceiling. The open staircase leads to a loft overlooking the living room, a bonus space for children's play activities near the bedrooms.

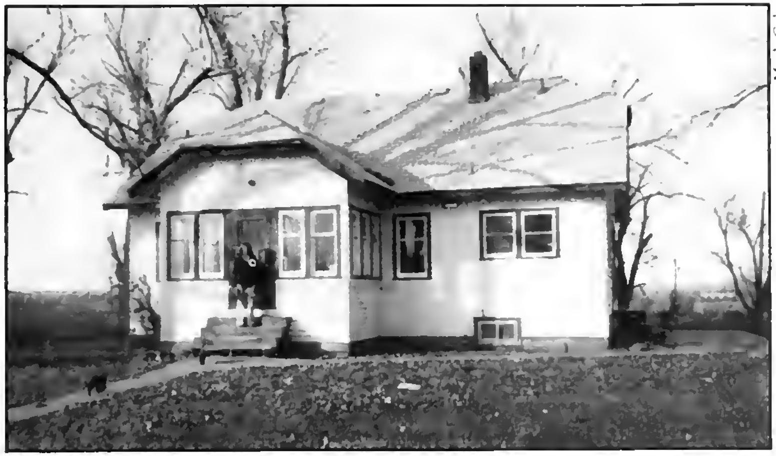
A Little House and a Big Idea

When Mark and Barbara Cole set about building a new house in July of 1983, they started with a small 50-year-old farm-house and a big idea. Essentially, they were going to build an addition and modify the little old house to make a big new house. The Coles never lived in the little house; they just bought it and the land it sat on for their building project. By the time the Coles moved into the new building in September of 1987, some people were asking them if they wouldn't have been better off to demolish the old house and start building with a flat spot on the ground. Mark Cole says no.

"The existing dwelling had an excellent floorplan, was extremely well built and integrated well with our plans to add an extensive addition. I very much doubt that it would have been easier to start fresh."

A Place to Start

One of the first operations was digging down next to the foundation of the existing house and knocking a big hole through the concrete so a front-end loader could get in to remove the deteriorated floor of the basement. The old siding was removed, as were the old shingles on the roof. New basement foundation walls were poured to accommodate the new portion of the structure. Double 2 x 4 stud walls were built on the new foundation. On the old part of the house, Larsen trusses (see Glossary) were installed on the outside of the walls to allow room for insulation. In the new walls, both the



Mark Cole

Before: The 50-year-old farmhouse that the Coles started with.

John Riggs

After The Coles' new house, built around the old house.

Owners
Mark and Barbara Cole

Location
East of Miles City

Designer
Owners

Builder
Bryce H Richards
1020 South Cottage Grove
Miles City, MT 59301

Style
Cathedral

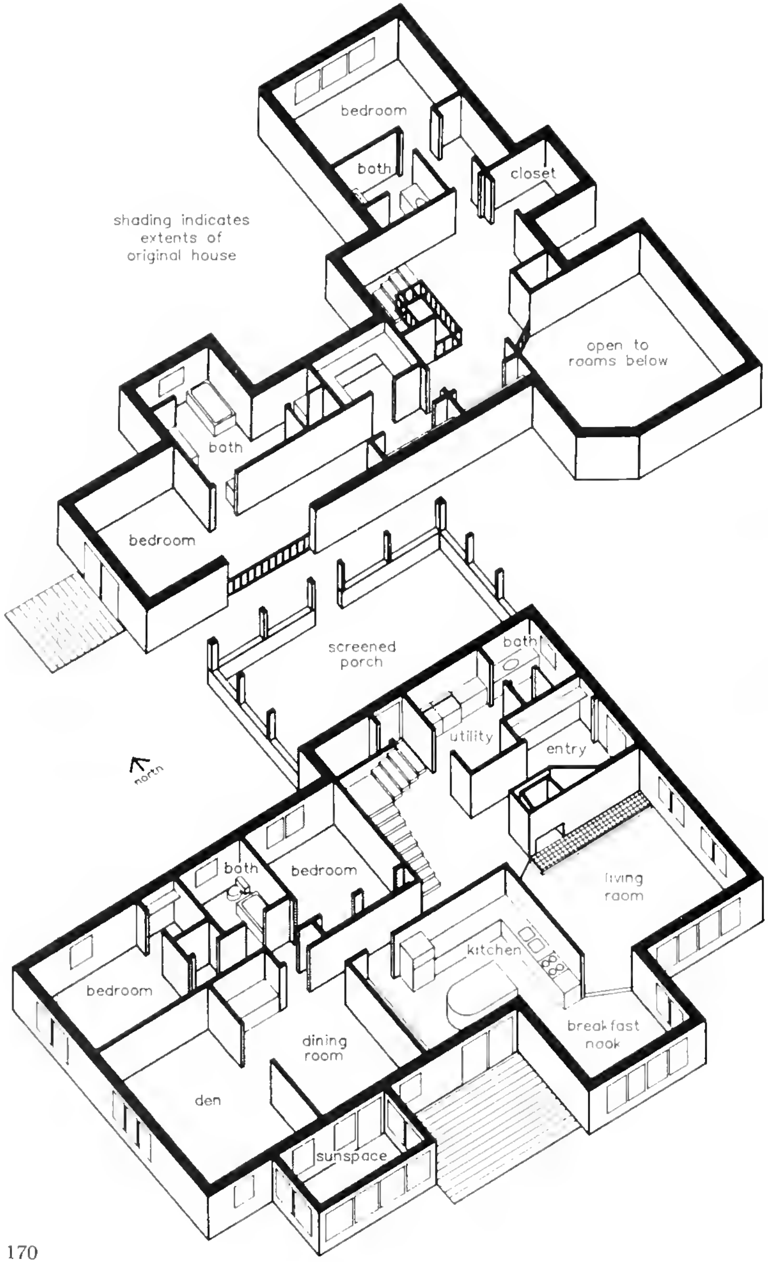
Insulation
Roof - R35 Added to Pre-existing house
R57 in Addition
Double Walls - R36
Larsen Truss Walls - R41
Basement Walls and Slab - R10

Square Feet
Upper - 1,182
Main - 2,386
Basement - 2,834
Sun Porch - 112
Screened Porch - 448

Special Features
Major Addition to Existing House
Larsen Trusses
Four Pulse Furnaces
Triple Pane Windows
Recirculating Water Heaters
Superinsulation

Heat
Passive Solar Propane Pulse Furnaces

Completed
September 1987



inner and outer stud walls were sheathed with 1/2-inch plywood on the sides facing to the outside of the house. Although it is not customary to sheath the inner wall, Mark explained that it was necessary in this case because the inner wall is the bearing wall. Besides, he said, it only required about $200 worth of plywood.

A 9-mil cross-woven polyethylene air-vapor barrier was applied over the sheathing on the inner wall. The air-vapor barrier is continuous, and was installed under the drywall on the ceilings. A 14-mil cross-woven polyethylene moisture barrier was applied to the exterior of the basement walls, with 2-inch boards of extruded polystyrene insulation installed over the barrier.

Modern Technology for Old and New

Both the new walls and the retrofitted walls were insulated with 3 1/2 inches of fiberglass batt insulation in the spaces of the inner stud wall, with 9-inch batts applied to the spaces of the exterior wall and extending into the space between inner and outer walls. A Tyvek air barrier was applied between the outside sheathing and the Masonite siding.

A steep new roof was built over the joined old and new structures, using 18-inch TJI rafters (see Glossary) as support members. The new roof was insulated with two layers of fiberglass batts, one 12-inch and one 6-inch, for an R-value of 57. The old portion of the roof was insulated with 7 inches of extruded polystyrene, with an R35 value.

The main difficulty in joining the old and new structures was getting the floor levels and eave lines of the old structure to match those of the addition. Installation of Larsen trusses complicated the construction by changing the roof-wall junction, making it necessary to extend the rafter tails to provide the desired roof line.

Little House Disappears

As construction proceeded, the original little farmhouse with its Dutch hip roof gradually disappeared into the 7,000 square feet of floor space in the new house. A visitor to the new house finds it difficult to see any remnant of the old house. The only visible remainders are the oak floors in two rooms and a built-in china cabinet in the dining area. All the old windows were removed and replaced with the same type of triple-pane glazing used in the addition. The cathedral ceiling in the addition rises 23 feet, 6 inches from the living room floor. Exposed roof-support beams form eye-catching geometric patterns as they criss-cross the space near the ceiling apex.

Approximately 4,500 square feet of the Cole house are heated living space. To heat this space most efficiently, the Coles installed four Lennox pulse furnaces. Two of these furnaces heat the 2,386 square feet of the main floor. Mark said two furnaces were needed for the main level because it is divided into two areas, one for daytime living and the other for sleeping. These two areas have different heating and cooling requirements. The use of multiple furnaces simplifies the duct work, Mark said, and makes the heating much more uniform than it would be if a single furnace had to provide all the output. Three of the furnaces are rated at 60,000 Btu, and the one that heats the basement is rated at 40,000 Btu.

No Moisture Problems

Mark said he had duct work installed to accommodate two heat recovery ventilators to ventilate the house if necessary,

John Riggs

Exposed beams are an eye-catching element of the Cole house.

John Riggs

Two of the four propane-fired Pulse furnaces used to heat the Cole house. PVC pipes vent all these furnaces through walls to the outside.

but the ventilators themselves have not been installed yet. "I wanted to live in it for a season to see if we developed moisture problems," he said. So far, no such problems have occurred. The house is ventilated by the fans in the four furnaces, which are kept running all the time. Mark said the sheer volume of space in the house probably is a factor in the lack of moisture problems. "If we took showers and cooked in a house with 800 square feet the way we do in this house, I'm sure we would have problems," he said

Plenty of Hot Water

A direct vent (see Glossary) propane-fired water heater with 50 gallon storage provides domestic hot water, and an extra 50-gallon tank stores additional hot water. Both the water tanks and all hot water pipes are insulated to minimize heat losses. The hot water system is designed to keep the heated water circulating so hot water is immediately available when a tap is opened. Hot water also passes through an array of plastic tubing that heats the tile floors in the master bedroom and bathroom. Mark said that although it is pleasant to put his feet on a warm floor on a cold morning, the floor-heating system is somewhat complicated and he's not sure he'd put one in if he had it to do over.

The Joy of Energy Efficiency

After spending a fall, winter, and spring in their new house, the Coles have established the energy efficiency of the building. Review of their heat bills for this period reveals that less than $500 worth of propane was needed to heat the house in 1987. Propane is 43 cents a gallon in Miles City, much cheaper than in some other areas of Montana, and cheaper to heat with than electricity in the Miles City area.

Mark said the house normally is kept at 70 degrees while the Coles are home. When they are not home, and at night, the programmable thermostats are turned to the lowest setting, which keeps the furnaces from coming on under normal circumstances. "When it is 15 to 18 degrees outside," Mark said, "the house usually loses about 2 degrees overnight, dropping from 70 to 68." Despite the house's thermal efficiency, some design variations could have improved the energy efficiency. For example, Mark said, there is more glass than there should be for maximum energy savings. The glazing is nearly 20 percent of the total area of the south wall, he said, adding, "I am sure that my large windows create more heat loss than I gain from most of the superinsulation features." Energy bills are not a large part of the Coles budget, Mark said, and although insulated window coverings would save some energy, these are not being actively considered at the moment. "Any window treatments we do are likely to be aimed more at aesthetics than energy efficiency," he said

Payback Not Immediately in View

Mark said his records show that the energy efficiency features accounted for about 10 percent of the $63 per square foot construction cost. "Assuming current energy costs and interest rates," he said, "I doubt that I would see any savings in my lifetime, though I may be too pessimistic about that. We need to live in the house several more years before we know for sure."

Just What They Wanted

The Coles can't think of much they would do differently if they were building again. "Maybe line up my financing ahead of time, and do a little more planning," Mark said. Other than that, the place turned out just as they wanted it. "When you've got what you want, why try to improve upon it?" Mark said.

Surprisingly, he said, the construction was completed without any major gaffes. He credited the house's builder, Bryce Richards, with the problem-free construction. He said Richards is a craftsman "from the old school" of custom house building. Richards was the only carpenter on the job, taking four years to build the house. Nearly all of the construction other than carpentry was subcontracted. Mark and Barbara did the design themselves. □

Radiant Floors Offer Even Heat

Owners
Bill and Joyce Carr

Location
Missoula

Designer and Builder
Owners

Style
2 Story with Daylight Basement

Insulation
Ceiling - R55
2x6 Wall - R19
Basement Wall - R29

Square Feet
Main - 1,360
Basement - 1,360

Special Features
Heating System

Heat
Wood, Natural Gas Hydronic

Completed
December 1985

A cheery fire burning in the fireplace warms the floors throughout Joyce and Bill Carr's house. An Ultrafire custom-designed fireplace crafted of Feather River travertine rock serves as one heat source for the Carrs' radiant floor heating system.

When Bill, a forester with the U.S. Forest Service in Missoula, and his wife built their new house, they wanted a heating system that would use both wood and natural gas. But they didn't want to huddle in front of a fireplace while the rest of the house stayed cold. So, Bill contacted Frank Pawarski, who is an expert at designing custom hydronic heating systems.

Sunshine adds its warmth to Bill and Joyce Carr's home through large west- and south-facing windows. The roof overhang, deck, and insulated shades prevent overheating in the summer.

Circulating Liquid Distributes Heat

Frank designed a radiant floor system using more than 1,000 feet of 1/2-inch polybutylene tubing. The tubing was installed in the concrete slab of the basement and among the joists beneath the subfloor of the upper level. When a fire burns in the fireplace, it heats a water-antifreeze mixture which circulates through a heat exchanger in the fireplace and through the tubing, radiating an even heat underfoot.

A 200,000 Btu gas-fired Thermar instant hot water heater takes over to heat the water-antifreeze solution on days when the fireplace isn't in use. Direct vents feed outside air to the fireplace and Thermar heater.

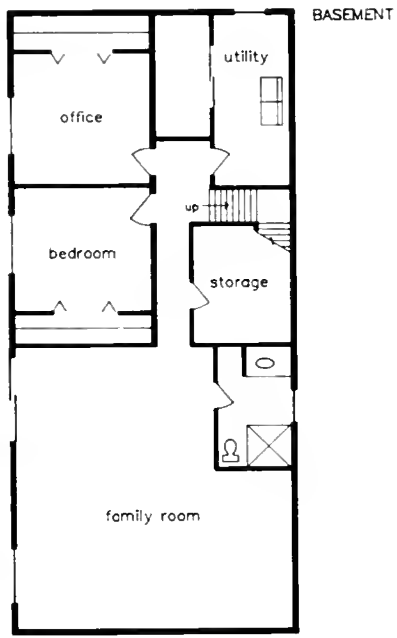
Segregating the tubing grid into four zones ensures that heat travels only to where it's needed. On the main floor, the area comprising living room, dining area, and kitchen is one zone, the bedrooms another, and the baths a third. The basement represents a fourth zone. When a zone's thermostat calls for heat, the valve serving the tubing in that zone opens and the heated solution circulates through the tubing, warming the floor. If none of the upper level zones are calling for heat and the temperature of the circulating solution exceeds 160 degrees, the valve to the basement zone automatically opens so the slab acts as a "dump" for excess heat. A manually operated valve controls a 500-foot loop of 3/4-inch polybutylene which heats the garage slab and acts as an additional heat dump.

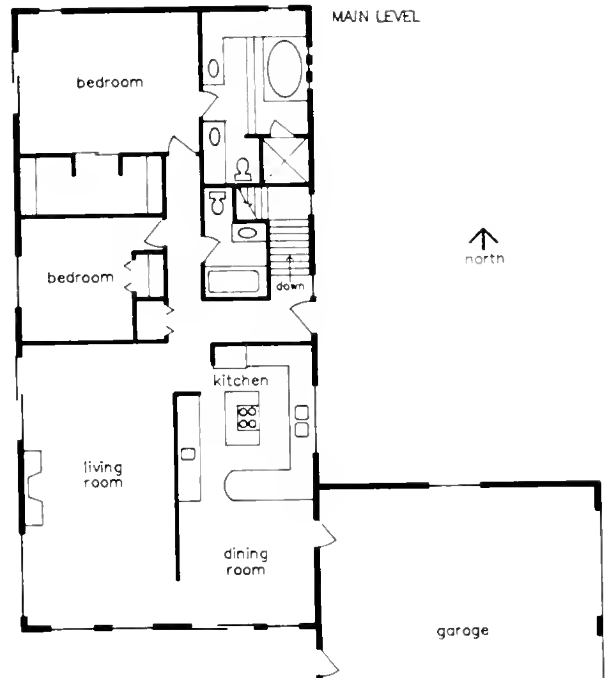
Besides the comfort the radiant floors provide, Bill noted that the cost of the system, excluding the fireplace, was less than half what an energy-efficient furnace would cost, and that it's virtually maintenance-free. "A sight-glass shows when the antifreeze mixture is getting low. So far, I haven't had to add any. A plastic drain tube is a precaution for too much moisture building up in the system, although that hasn't happened either," he said.

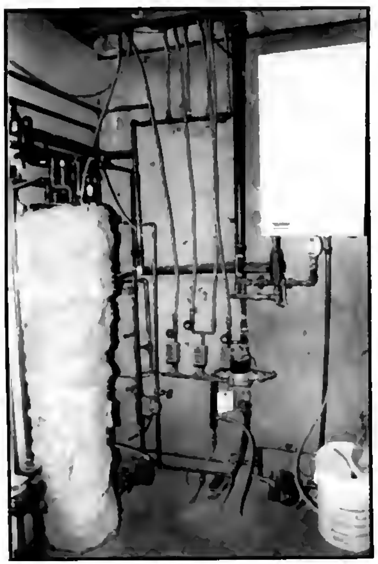
The Carrs heat 3,360 square feet of space. Bill's records show their gas bill is averaging less than $5.00 a month for space and hot water heating, but they are burning approximately 6 cords of wood during the heating season.

They Did It Themselves

The Carrs prepared themselves for the task of designing and building their home. "Joyce and I read everything we could find on energy-efficient homes. We gathered information from the Canadian energy studies, and attended several of the DNRC builder and owner training workshops. We learned about overhangs, orienting the house for solar gain, window insulation, and more," Bill said.







From the mechanical room, polybutylene tubing runs into the basement slab and overhead through the floor joists to distribute heat to the Carr's floors. When the fireplace is not in use, a Thermar instant water heater takes over to heat the liquid in the tubing.

Then they spent five months in an 11-foot pickup camper while they supervised the house construction and went to their daily jobs. "One thing about contracting your own house and living on site, is that you can make a lot of decisions on the fly. For instance, we designed the fireplace so the rock would extend to the outside. Advice from contractors was that the rock would leak heat like an open window, so we put insulated 2 x 6 walls between the fireplace and the outside. We made that change when the workmen were putting forms in for the basement which meant they had to extend the forming to accommodate the 2 x 6 framing around the fireplace."

Energy-Saving Construction

The sloping hillside shelters the entire east wall and about half of both ends of the daylight basement from brisk wintry weather. Two-inch extruded polystyrene was installed on the outside of the basement walls down to the frost line and 2 x 4 walls with 3 1/2-inch fiberglass batts were built on the interior side of the basement walls.

Fiberglass in the 2 x 6 walls and 16 inches of fiberglass and a 6-mil air-vapor barrier in the scissors-truss vaulted ceiling keep a lid on the heating bill. The Carrs did not install an air-vapor barrier in the walls or insulation under the slab. "We didn't want an airtight house with wood and gas heat," Bill said. Although they don't have a heat recovery ventilator, Bill said condensation hasn't been a problem. Fans in the kitchen and bath carry off excess moisture.

Passive solar gain, though not a major source of heat, does help to some degree. Double-glazed Clawson windows with low-E film trap the sun's heat on clear winter days. Most of the windows are on the south and west. "We have only two small windows on the north," Bill said, "one in the master bedroom and one in the adjoining bath. Insulated shades add extra R-value to the windows when pulled.

One thing that concerns Bill is the amount of heat trapped between the insulated shades and the windows in the summer. "The reflective window film keeps the heat in," he explained. "So, when we close the shades, we open the windows just a bit to let some of the heat escape."

All in all, the house satisfies the Carrs. "I haven't thought of ways to improve on it yet," Bill said. "It's a very comfortable home, no cold or hot spots, and very quiet. It stays cool in the summer if we draw the shades." □

A specially designed fireplace serves as one heat source for the Carr's radiant floor heating system. Insulated shades, shown stacked at the tops of the adjacent windows, pull down to restrict heat loss on chilly nights.

Blizzards Seen But Not Heard

In the Rattlesnake area north of Missoula, Mike and Mabelle Hardy's house stands sturdy against the winds that rake the ridge. Its triple-shed roofline sweeps the cold winter blasts up and over the house, and earth-berm protection of the lower portions gives further shelter. Sunlight pours into the sunspace where its free heat is captured and circulated throughout the house.

These design features do not exist by accident. Mostly, they were the ideas of the Hardys, who gave them to Missoula architect Jay Kirby with instructions to give them substance. "I'd figured and figured trying to fit the rooms we wanted into this site. Jay managed to accomplish our goals and save us energy too," Mike said.

A "great room" met one of those goals. "We wanted our living and dining activities in one room," Mabelle said. "We needed space for my piano and for the harpsichord that Mike built for me, and we had many antiques to find room for." Up a half flight of stairs from the front airlock entry, the room looks out on a panorama of the Missoula valley and the Rattlesnake Wilderness Area. Natural light streams through ceiling-high windows to the farthest reaches of the room. Insulated French doors lead to the deck across the front of the house.

Sunspace for Coffee and Comfort

From the dining area of the great room, a glass door opens into the sunspace on the south side of the house. Mike Hardy ran his hand over the red brick Trombe wall separating the sunspace from the great room, kitchen, and master bedroom. "This is actually a concrete wall poured in forms that make it look like brick. The brick pattern was also used for the inside walls of the basement." He pointed out the textured brushed-concrete floor. "Both the wall and the floor store tremendous amounts of heat through the day. At night the heat radiates to the sunspace and the living areas. It's still a surprise to find warm dishes in the cupboards."

Window Quilt shades slip snugly through side casings to seal the double-glazed windows against heat loss at night. "Although we have only the sun for warmth in the sunspace, during the three winters we've been in the house, this room has never dropped below 50 degrees, even when it was 30 degrees below zero outside," Mike said.

A lawn and terraced garden are accessible from the sunspace. The sunspace also has doors into the kitchen and master bedroom. Mabelle said that she tried to talk the architect into leaving out the door to the kitchen so she'd have more wall space. "I'm so glad Jay didn't let me. We like to take our morning coffee in the sunspace, and I love to have the door open into the sunspace while I'm working here in the kitchen."

A triple-shed roofline, earth sheltering, and plenty of south-facing windows buffer Mike and Mabelle Hardy's home against the elements.

Owners
Mike and Mabelle Hardy

Location
Missoula

Designer
Jay Kirby, Architect
2011 South Fourth Street
Missoula, MT 59821
549-9941

Builder
South Wall Builders
644 South Second Street West
Missoula, MT 59807
549-7678

Style
1 Story with Finished Basement

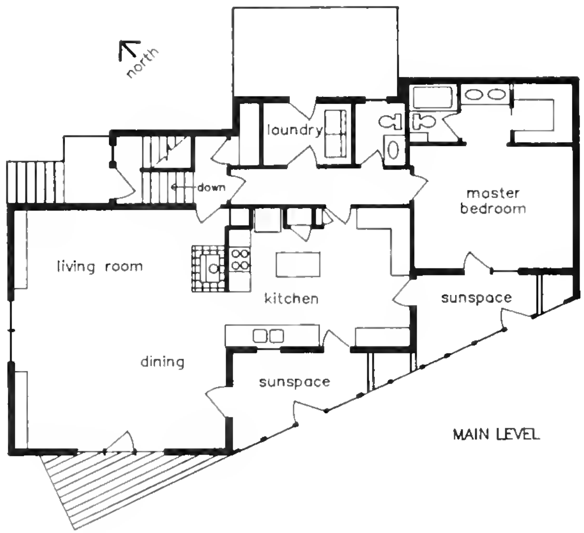
Insulation
Ceiling - R54
2 x 6 Walls - R35
Basement Walls - R23/12
R23 to 4 feet below ground
R12 from 4 feet below ground to footings
Slab - R12

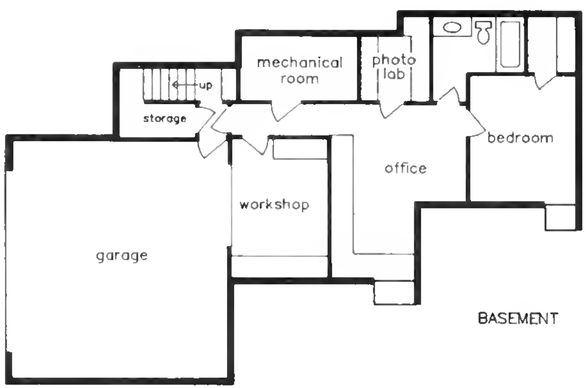
Square Feet
Main - 1,334
Basement - 1,101

Special Features
Sunspace
Thermal Storage
Earth Tube Integrated with AAHX
Earth Sheltered

Heat
Passive Solar, Electric, Wood

Completed
January 1984





Kitchen Accommodates Interests

"Everything I need for cooking or sewing is in this kitchen," Mabelle said. "On this island I can cut out dough or fabric. The built-in marble slab is perfect for rolling out pie crust or cooling candy. In this corner is my sewing machine; over here is my office and cookbook center," Mabelle said, gesturing to the built-in desk and bookshelves. Violets thrive under a Gro-lite on a shelf above the sewing center. Oak cabinets line the walls; glass cupboard doors show off the Hardy's pottery collection. Almond-colored appliances, a cleaning supplies closet, and pantry complete the tidy kitchen.

Fresh Air in the Bedroom

"Because this door doesn't open directly to the outside, Jay recommended a sliding glass door," Mabelle said, sliding open the door from the sunspace into the master bedroom. "I'm also somewhat claustrophobic and have always slept with a window open. Well, I couldn't do that and save energy, too, so to compensate, the vent for the fresh air from the air exchanger is behind the head of the bed. Feeling that slight current of air helps put my anxieties to rest."

A ceiling fan in the master bedroom circulates the warmth pouring in from the sunspace. High above the bed, a window brings in light. "Up to that shelf mounted just below the window, the wall is sheltered by the ground," Mike said. "South Wall Builders designed the shelf to obscure the seam where concrete meets wood. It has really come in handy for displaying some of our treasures."

Sea-green carpeting and green patterned wallpaper in the bedroom and dressing area continue the cheerful colors of the sunspace plants. In the master bath, a whirlpool bath waits to soothe sore muscles.

Mike pointed out the three small windows on the north side of the home in the two bathrooms and the laundry. "We had to persuade Jay and Steve (Steve Loken, partner in South Wall Builders) to put them in. They were both reluctant to poke any holes through the north walls. Every time we drive a picture hook into an external wall, we can just see Steve cringe. But, I cut the nails short so they don't penetrate the vapor barrier."

The laundry room doubles as a mud room and leads to a small deck. "This deck is nice in the summer since it's shielded from the hot afternoon sun," Mabelle said.

Window Wells Bring in Daylight

Window wells cut into the sunspace floor and Trombe wall serve as safety exits and bring daylight into Mike's office and a spare bedroom downstairs. Removable grills in the sunspace floor prevent people from stepping into the window wells. "The window wells were Jay's idea, too. It's encouraging to be able to see the sun when I'm down here writing," Mike said. After a career with the U.S. Forest Service, Mike has just spent the past year preparing a book on agricultural aircraft.

Beneath the Surface

Many of the energy-efficient features in the house are not readily visible. Four-inch-thick extruded polystyrene was installed on the exterior of the concrete walls from the top to 4 feet below ground, with 2 inches of the same material down to the footings and under the slab. Insulating the foundation on the exterior left

the interior concrete free to soak up heat. The concrete walls, the slab, and the interior of the house beneath the drywall are wrapped with a 6-mil TuTuff air-vapor barrier that has been caulked at every seam and penetration. Beneath the cedar siding, 1-inch urethane sheathing forms an air barrier.

Blown-in-cellulose insulates the cavities of the framed 2 x 6 walls. Just after the contractor blew in the insulation, a cold snap (-20 degrees) descended on the area. It took the cellulose a month to dry. The architect said in future construction he'd prefer to use blown-in-batts of fiberglass, which dries faster than cellulose. The ceiling has two layers of fiberglass batts (10 inches and 6 inches thick).

Earth Tube-Coupled Ventilation

A Memphremagog Echo Changer heat recovery ventilator runs continuously at the low speed of 120 cubic feet per minute. This rate can be increased to 180 cubic feet per minute by manually turning on the kitchen or bathroom fans which are part of the system. "On the slow speed, we get a complete air exchange about every 2 1/2 hours," Mike said. "We've never had any trouble with condensation. In fact this home is moisture-poor, and I've been working on a way to introduce more moisture."

An earth tube tempers air coming into the air exchanger. Outside air enters the tube at the northeast corner of the home and travels down 18 feet to a bend in the tube. The air then travels horizontally through 40 feet of buried tube to the "mechanical" room where it enters the air exchanger. The ground temperature boosts the outside winter air to 40 degrees. After passing through the air exchanger, the air enters the rooms at 60 degrees. Mike said the 20-degree increase in air temperature is gained through heat exchange between the air being exhausted from the house and the incoming air. The temperature of the air being removed from the house is reduced from 75 degrees to 55 degrees.

Tracking the Heating Costs

A Kent tile wood stove near the great room entry, two 6-foot electric baseboard heaters, and an electric fan-assisted heater in the toe space beneath the kitchen island aid the sun in heating the great room and kitchen. Small zoned baseboard heaters assist in the bedroom and baths. Mike knows exactly how much heat they use. A separate meter tracks the electricity for heating, and he weighs the wood used. "I know the Btu of each species and know what the moisture content is. I convert the Btus to kilowatt-hours. My records for the past three years show that wood (1.1 cord a year) accounts for 40 percent of the total kilowatts used, but only 14 percent of the total annual cost of $484. Excluding the garage and shop,

The great room wall provides ample space for a large quilt made by Mabelle's grandmother and a number of watercolor paintings. Honey-colored carpeting harmonizes with the muted hues of the paintings and the soft patina of antique chairs and tables. A step down from the dining area is a cheery sunspace.

On clear winter days, sunlight fills the Hardy's south-facing sunspace. Double glazing and Window Quilts trap the heat soaked up by the concrete.

Track lighting in the great room provides illumination with minimal penetrations through the ceiling air-vapor barrier.

which are rarely heated, we average 8.11 kilowatt-hours per square foot. But high ceilings in the main living areas add a lot of space to our rooms so I figured the usage based on the volume of the house; it comes out to 0.78 kilowatt-hours per cubic foot. I believe anything less than 2.00 kilowatt-hours per cubic foot is considered good."

The Hardys are currently in the process of making some small improvements in their house. Adding a skylight in the kitchen will admit extra natural light to make food preparation, sewing, and reading more pleasant on dull days. Replacing a conventional window in the great room with a bay window will make it easier to see the elk which often roam the hills to the north.

Calculating Building Costs

Mike said about 15 percent of the $51 per square foot construction cost can be attributed to installing the extra insulation and passive solar beyond what normally would be included in a conventional house with 2 x 4 walls. "It may never be cost effective, although power rates have increased about twenty percent since we moved in," Mike said. "We used 100 cubic yards of concrete in the house, a lot of which was for the thermal mass in the sunspace. But we would have had a sunspace in any plan, and we wouldn't have built a home without 2 x 6 walls. At any rate, we are snug, pleased, and proud."

"This home is truly part of us," Mabelle said. "We love watching the sunrises and sunsets and the changing colors in the clouds as they move over the Bitterroot Range into the valley. And we enjoy the quiet. Although the wind blows hard up here most of the time, we simply don't hear it. We have to look outside to know that we're having a blizzard." □

Quality Tells the Tale

Experience shows that state-of-the art design and painstaking construction are two of the keys to new houses with low energy consumption. Both these strategies were employed in the 3,000 square foot house built for Charles and Bonnee Mekeal, with the result that it costs less than $250 per year to heat the living space and water in this sizable and attractive structure. Natural gas bills in the winter average about $1 per day for both heat and water.

The Mekeal house, located on a hillside subdivision lot in the Grant Creek drainage north of Missoula, is superinsulated, with thick exterior walls incorporating double 2 x 4 stud wall construction (see Glossary). The outer stud wall in the exterior wall is built of 2 x 4s on 16-inch centers, and the inner stud wall is built on 24-inch centers, with a 4-inch space between the walls. Both the inner and outer stud wall components of the exterior wall are insulated with R11 fiberglass batts, and a layer of R11 batts was placed horizontally in the space between them. R4 polyisocyanurate sheathing was applied to outside walls under the siding. Total insulating value of the fiberglass batts and polyisocyanurate sheathing is R37.

Tremco an Essential Ingredient

The air-vapor barrier is sealed with Tremco acoustical sealant wherever it overlaps or where plumbing, wiring, or other equipment penetrates it. Tremco does not dry out, crack, or lose its

The Mekeal house demonstrates that superinsulated houses need not be boxes with tiny windows.

Solar warmth and natural light help make the Mekeals' living room inviting.

Owners
Charles and Bonnee Mekeal

Location
North of Missoula

Designer
James Hoffman
315 South Fourth East
Missoula, MT 59801
728-8847

Builder
Strate Builders
330 South California
Missoula, MT 59801
549-4291

Style
2 Story with Daylight Basement

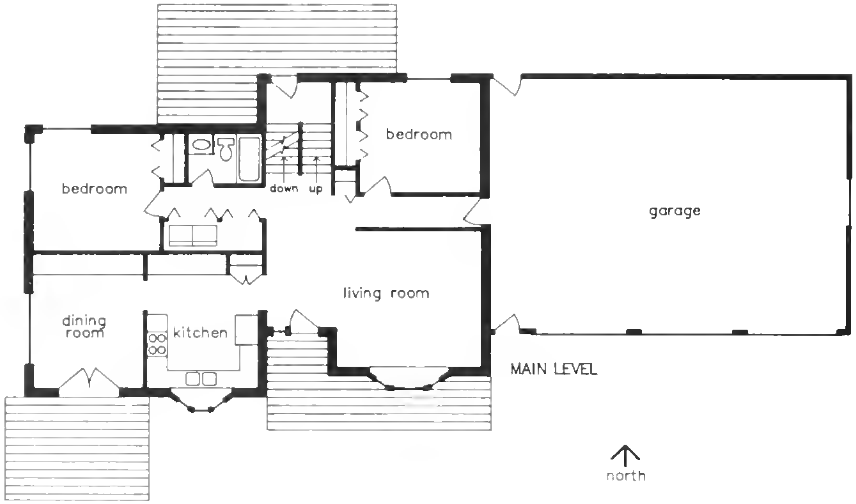
Insulation
Ceiling - R60
Double Walls - R37
Basement Walls - R19
Under Slab - R7.5

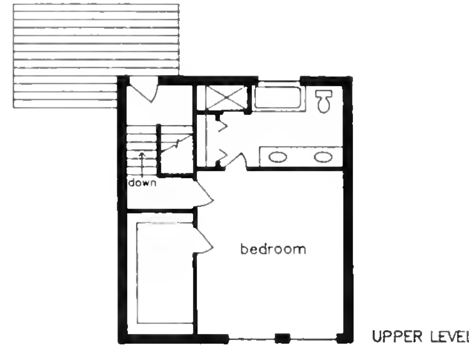
Square Feet
Upper - 593
Main - 1,284
Basement - 1,284

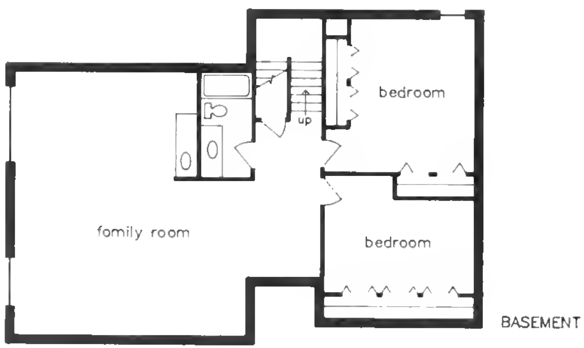
Special Features
Superinsulation
Low-E Glass

Heat
High-efficiency Gas Furnace

Completed
December 1985







adhesive abilities with age, and so is highly effective in sealing leaks and preserving the air-vapor barrier over the long term.

The ceiling air-vapor barrier is 6-mil polyethylene, also sealed with Tremco. The ceiling insulation is blown-in fiberglass with an R-value of 60. The basement is finished with a 2 x 4 stud wall on 24-inch centers, set out 2 inches from the concrete wall and insulated with 6-inch R19 fiberglass batts. The basement stud wall has a 4-mil polyethylene air-vapor barrier and 5/8-inch drywall. An inch and a half of extruded polystyrene foam board insulation (R7.5) was placed under the 4-inch basement floor slab.

Cool House Preferred

The Mekeals like a relatively cool house, and keep the living space at about 62 degrees. Heat is provided with a Coleman 43,000 Btu 94-percent-efficient gas-fired condensing furnace. This furnace is vented through an outside wall.

Large windows on the south side take advantage of any sun that is available, but nearby hills limit the amount of sunlight available in the winter months. All windows are Clawson double-pane with low-E glass. Exterior doors are foam-core steel with an R-value of 13.

Indoor air quality is controlled with an E-Z Vent heat recovery ventilator. Charles said the ventilator is set to run automatically in the afternoon. The Mekeals also operate the exchanger in manual mode to clear out the humidity when they take showers.

The Small Cost of Superinsulation

The total construction cost of the Mekeal house was $97,000. Dave Strate of Strate Builders said it cost about $4,000 more to build the house to superinsulation standards than it would have cost to build it to present HUD standards. □

Historic Retrofit Builds in Comfort and Energy Savings

Missoula's university district offers big trees, wide streets, and handsome homes within walking distance of downtown, schools, and parks. Its residents are reluctant to move away. So when Lindsay Richards and her husband, Tom Roberts, were caught in a space crunch, they chose to expand their house and stay put. Part of the expansion was also an energy upgrade.

"It was a unique retrofit," commented John Lentz, a partner in Southwall Builders, which did the reworking. "The owners wanted to keep as much of the existing house as possible and wanted the new to match the old." Over a period of four months, John and his partner, Steve Loken, skillfully tightened and expanded the 55-year-old house. The result is a seamless blending of new and old.

Carefully matched and applied stucco blends the addition (right and second story) with the original structure of this Missoula house. A new exterior acrylic-based material coats the stucco to help stop air infiltration.

Tightening the First Floor

Like many older houses, the house was short on insulation, but it did have some intrinsic advantages. John remarked that the long axis of the house faced south, which gave it modest solar gain, and that its taupe-brown stucco exterior absorbed and held warmth from the sun. John and Steve's job was to tighten the house so it retained the heat. From the interior side, the 2 x 4 walls were drilled and filled with blown-in-blanket insulation (BIBS). "It was easier to drill lath and plaster than stucco, so we did the retrofit from the interior side," John explained. John and Steve left the period windows in place and installed exterior storm windows. They also added interior plexiglass storm windows to the two windows on the north side.

One of the additions is a new entry that brings visitors into a foyer instead of directly into the living room. The foyer's specially crafted molding and arched ceiling echo the distinctive molding and arches found in the original house. Newly sanded and varnished oak floors provide a pleasant continuity between the living room, dining room, and playroom. Plaster walls painted off-white complement the natural finish of the wide baseboard molding.

Adding the Second Story

Space for the new second story was gained by tearing off the old roof and raising the sidewalls 6 feet. "We put up new rafters and built dormers," John said. "We insulated with BIBS in the ceiling and in the 2 x 6 walls, and used the airtight drywall technique for the air-vapor barrier." Natural daylight filters into the upstairs hallway through a deep skylight. Just below the skylight, John pointed out the cold air return vent that keeps the air circulating and prevents condensation.

Owners
Lindsay Richards and Tom Roberts

Location
Missoula

Designer
James Hoffman
315 South Fourth East
Missoula, MT 59807
728-8847

Builder
Southwall Builders
644 South Second West
Missoula, MT 59807
549-7678

Style
Retrofit

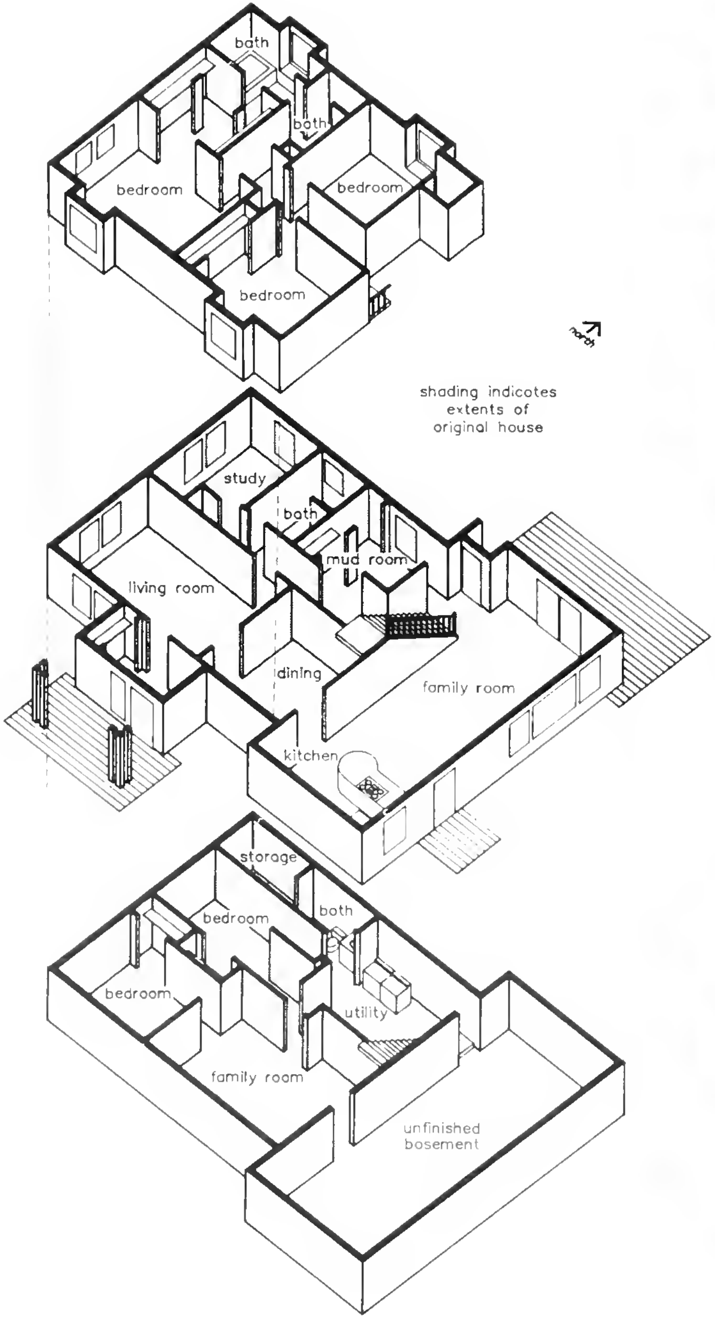
Insulation
Ceiling - R50
2 x 4 Wall - R15
2 x 6 Walls - R29
Basement Wall - R19
Slab - R5

Square Feet
Upper - 896
Main - 1,128
Basement - 1,128

Special Features
Blend of Old and New
Airtight Drywall
Earth Tube

Heat
Natural Gas

Completed
November 1986



Arched doorways and cherrywood staircase connect the new family room and upstairs addition to the original portion of the house. Airtight drywall restricts the escape of warmed air to the outside.

A small skylight brings natural light into the large bath serving the three upstairs bedrooms. The rich hues of the cherrywood vanities contrast pleasantly with the light almond-colored tile and tub. A walk-through dressing room conveniently links master bedroom to bath.

Quiet fans were installed in both bathrooms and the kitchen to exhaust moisture and odors. The fans are controlled by a dehumidistat or can be operated manually. Quality back-draft dampers prevent outside air from entering the house through the fan ductwork.

New Family Room-Kitchen

An airy 18 x 36-foot addition houses a spacious family room and kitchen. The new walls and ceiling are filled with BIBS, and the vaulted part of the ceiling is sheathed with 1 inch of polyisocyanurate. Several pairs of double-glazed windows admit natural light.

A peninsula with Jenn-Air set-in range divides the family room from the kitchen. Its expansive surface offers plenty of room for informal meals or food preparation. The rich grain of cherrywood with inlaid walnut is continued in the strikingly handsome kitchen cabinets and in the balusters and handrail of the stairs leading upstairs from the family room.

Basement Retrofit

Basement walls are insulated with a 2 x 4 stud wall and finished with airtight drywall. "We also placed fiberglass between the floor joists next to the rim joists. We put 1-inch Thermax over the fiberglass, glued the ends to the floor joists, then sealed all edges with caulk," John said. An earth tube brings fresh air into the basement. This air warms and slowly filters to the rest of the house. The earth tube extends straight down approximately 5 feet from ground surface to the foundation, passes under the foundation and comes up through the basement slab.

The existing gas furnace was fairly new, so it was not replaced. A thorough tune-up boosted its efficiency to approximately 75 percent.

The retrofit gained more than space for Lindsay and Tom and their two young children. "Although we more than doubled our primary living space, we've had only a slight increase in our heating bill," Lindsay said. "It's much more comfortable now, especially during the colder months of the year. The house keeps a uniform temperature throughout, without any of the cold spots or drafts that we had before." By remodeling instead of moving, Lindsay and Tom were able to continue living close to their offices and their children could remain in the same school. □

When cutting the opening (far archway) to give access to the new kitchen, the builders meticulously copied the existing archway between living room and dining room. To match the older windows, triple panes decorate the top panel of new double-glazed windows in the kitchen and family room.

Reluctant Yankees Spurn Superinsulation

Owners
Harley and Jean Hankins

Location
Opheim

Designer
Owners and Builder

Builder
D & D Construction Company
P.O. Box 101
Sutherland Sub P.O.
Saskatoon, Saskatchewan
Canada S7N 2HO

Style
1 Story with Basement

Insulation
Ceiling - R60
Double Walls - R40
Basement Walls - R11

Square Feet
Main - 1,028
Basement - 1,028

Special Features
Pre-built Construction
Superinsulation

Heat
Passive Solar, Electric Baseboard

Completed
1983

The winter weather in Opheim, Montana, is like the winter weather in the rest of Montana, except more so. Opheim is located north of Glasgow and about 10 miles south of the Canadian border. It is on the main track of the rambunctious winter storms that roar down from the north. Opheim residents Harley and Jean Hankins were thinking about these storms when they decided to buy a new house. They knew about superinsulation and other methods of reducing energy costs, but nearby builders were not interested in building such a house, Harley said. Builders told the Hankins that insulation above R21 in the walls was not cost effective. "The Yankee builders I talked to were barely polite in turning down my proposal to build this house," Harley said.

Disgusted with this attitude, the Hankins decided to look north of the border for a more agreeable point of view. Their research told them that there were Canadian pre-built homes manufactured the way the Hankins wanted them. Looking into this further, they found a Canadian firm, D&D Construction of Saskatoon, which had a house model that the Hankins thought would fill the bill in Opheim. They found out about the Canadian firm through an article in Mother Earth News, Number 75.

Superinsulation and energy-efficient building practices make the Hankins house largely immune to winter. Note the tree which helps shade the south windows in summer, but admits sun in winter.

Canadians Provide Portable Comfort

The Canadian house the Hankins found has a double outer wall built with two 2 x 4 stud walls separated by a 4-inch space. The studs in these walls are 16 inches on center. The spaces between studs were insulated with vertical fiberglass batts, and the space between the walls was filled with similar batts running horizontally. Three layers of R11 batts brought the wall insulation up to R33. Fiberglass insulation was blown into the attic to a value of R60. A continuous 6-mil polyethylene air-vapor barrier was installed on the back of the inner stud wall. All windows are triple pane, and doors are insulated steel.

The house is equipped with electric baseboard heaters and a VanEE heat recovery ventilator. Cost of the basic two-bedroom house was $37.30 Canadian ($26.86 U.S.) per square foot. The choice of several more expensive options drove this up to $39.50 ($28.47 U.S.) per square foot. Total cost of the 1,028 square foot house was $40,650 ($29,268). The charge to haul it the 240 miles from Saskatoon and install it on the Hankins' foundation came to another $1,000 U.S.,and U.S. Customs required $2,321 to allow it across the border. This brought the total cost of the house in U.S. dollars to about $32,500, or $31.68 per square foot.

House Delivered in One Piece

The house was delivered in one piece, complete with all fixtures including lights and carpeting, ready to be occupied. The delivery crew placed the house on Hankins' basement with no problem.

Soffits on the Hankins house have continuous vents.

That was in 1983, and the Hankins have been living in the house ever since.

Was it worth all the trouble? The Hankins say yes. They knew what they wanted, and now they have it. "I wouldn't change a damned thing," Harley said. "Except I guess I'd use quadruple-pane glass instead of the triple panes." Even with electric heat, which tends to be more expensive than most other heating systems, heating bills run less than $200 per year. Harley said that even though electricity is more costly per Btu, the use of electric heat eliminates penetrations to the outside, which saves heat, and may make up the difference. "I don't lose 'em [Btu] up a chimney," he said.

Tips for House Importers

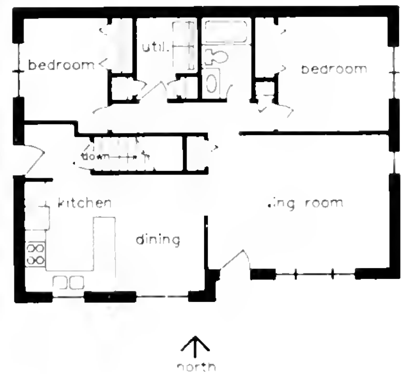
Harley has some tips for anyone wishing to import a pre-built house from Canada. For one thing, anyone bringing a house across the border should hire a broker ahead of time to take care of the import formalities. Harley said the broker he hired was from Plentywood, cost $20, and saved him no end of headaches. The Customs agents can tell you who the brokers are.

Once the house is across the border, Montana laws pertaining to oversize loads come into play. Permits for wide loads are issued by the Collections and Licensing Bureau in the Montana Department of Highways. Harley said the state authorities at first told him there was no way he could be allowed to haul his 26-foot-wide house on the highway, but, being a retired Master Sergeant, he "argued a bit," and a way was found. Anyone considering moving a house should check state regulations early in the game.

Canadian Builders Strongly Recommended

Harley strongly recommended D&D Construction for anyone in his vicinity wanting a pre-built, energy-efficient house. He said the Canadians were knowlegeable and went to great lengths to be accommodating, calling several times to update him on construction progress, and even taking Harley and Jean to dinner in a nice restaurant. □

The Hankins' living room is uniformly warm and draft free in any weather.



That "Made in Montana" Feeling

Owner
Ron Trosper

Location
West of Ronan

Designer
Owner and Jay Kirby, Architect
2011 South Fourth West
Missoula, MT 59801

Builder
Peter Rohfleisch
St. Ignatius, MT 59865

Style
Single Level, Underground

Insulation
Roof - R28
Rear Wall - R14
Front and Side Walls - R19
Under Slab - R10

Square Feet
1,140

Special Features
Earth Sheltering
Trombe Wall
Post and Beam Construction
Outside Combustion Air

Heat
Passive Solar, Wood, Electric

Completed
August 1984

When Ron Trosper looked at Jay Kirby's unique polygonal house in Arlee (see write-up on Kirby's house under "Arlee" in this book), he saw much that he wanted to incorporate in the new house he was planning to have built for himself near Ronan. Logically, he hired Kirby to draw the plans. Among the features that Trosper wanted were the heavy log ceiling beams, earth-sheltered design, extensive stonework, Trombe wall, and post-and-beam construction.

In its sparsely populated rural location, this individualistic dwelling makes good use of all the elements borrowed from the Kirby house, and adds a few more. Backed into the south-facing edge of a ravine with a sweeping view of the Mission Mountains to the southeast, the Trosper house has a "made in Montana" feeling.

The Trosper house has that "Made in Montana" look. Note intake pipe for outside combustion air.

Convex and Underground

A wedge-shaped section in the middle of the house gives the structure a convex shape. This design reduces the length of the rear wall, which is costly to build because of the strength needed to retain the earth behind it, but still leaves plenty of front wall for windows. The wedge-shaped section is occupied by a living room/dining room with floor-to-ceiling windows across its entire front. Just inside the mid-portion of this window expanse is a ceiling-height stone wall that acts as a solar collector and also contains a wood-burning fireplace. Solar heat is captured both by the massive stone masonry in the Trombe wall (see Glossary) and by the dark reddish brown tile on the living room floor. Heat stored in the masonry radiates back into the room when temperatures drop.

Rectangular spaces flank the wedge-shaped section on the east and west. The rectangular section on the east contains the kitchen, root cellar, utility and storage areas. The single bedroom and bath occupy the west rectangle. Total floor space is 1,140 square feet.

Roof with Grass

The log roof beams in the Trosper house are 16 inches in diameter at the small end. These larch beams are prominently visible from inside and provide a feeling of massive strength as they rise with the slope of the ceiling from 9 feet in the front to 10 feet 6 inches at the rear of the living room. The strength of these beams is needed to hold up the 4 x 6 inch roof decking, the 2 inches of gravel and 12 inches of dirt that make up the roof. Crested wheat grass on the roof requires little watering.

Insulation, and a Cozy Fire

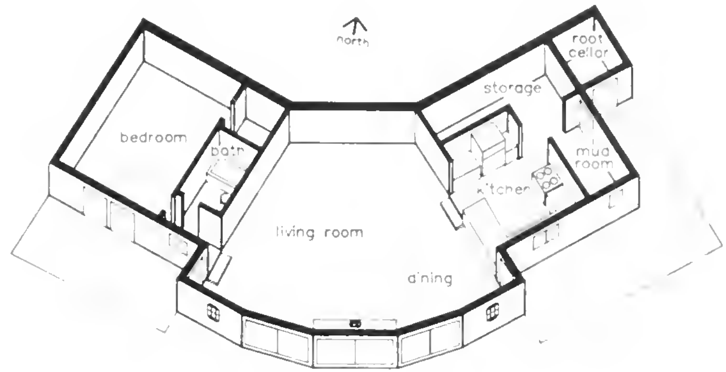
Four inches of polyurethane foam board insulation was applied over the 4 x 6 roof decking. A continuous layer of

Massive roof beams and fine stone masonry characterize the inside of the Trosper house.

polyurethane was sprayed as waterproofing over the polyurethane foam boards. The outside of the rear wall is insulated with 2 inches of the same type polyurethane foam boards applied to the roof. A Tu-Tuf moisture barrier was installed over this insulation. Under the floor slab, 2 inches of extruded polystyrene foam board and a polyethylene moisture barrier exclude moisture and prevent heat loss. The front and side walls are single-thickness 2 x 6 stud walls insulated with R19 fiberglass batts. These walls include a 6-mil polyethylene air-vapor barrier under the drywall. All glazing is double pane.

The main weather-protection strategy for the house is the earth-sheltered design. The house is sunk to a level below the top of the hill behind it, so the north wind sweeps over without resistance.

The wood-burning fireplace provides heat on winter evenings. The efficiency of the fireplace was improved by piping combustion air from outside, so warm room air is not sucked up the chimney.



Two 225 cubic feet-per-minute fans pull air into vents in the fireplace masonry near the ceiling, draw it down through an air passage surrounding the flue and the hot metal firebox, and then discharge it through vents into the living space. Electric baseboard heaters maintain temperatures during the day.

An 80-degree Man

Although the house is occupied only part of each day, the heat bills may be higher than they normally would be because Ron likes to keep the temperature above what most people would prefer. "I'm an 80-degree man," he said. During exceptionally cold winter weather, Ron's monthly electric bills run as high as $60, compared to about $20 in summer and $30 in spring and fall. These bills include all electrical use in the house.

Ron has used 2 cords or less of firewood during each of the four years he has lived in the house. A paddle fan on the ceiling near the fireplace helps circulate warm air in the house. Ron said the large south-facing windows and Trombe wall help heat the house in fall and spring, but the cloudy Mission valley winters largely prevent solar heating during December, January, and February.

Rugged Individualism Can Cost

Cost appears to be one drawback of rugged-individual type houses such as Ron's. The 1,140 square feet of floor space in Ron's house cost $60,000, or about $53 per square foot. Nevertheless, Ron is happy with his house, and has not had any structural problems. The structure is adequate to support the heavy roof, and the problems most common with underground houses, roof and wall leaks, have never occurred. □

Visiting salesmen have trouble finding the Trosper house, which shows only its chimney and vent pipes from the back side (at right of photo).

Tropical Montana Discovered

Owners
Hazel and Martin Wersland

Location
South of Sidney

Designer
Owners and Builder

Builder
Ken Wersland
Wersland Construction
1205 14th Street S.W
Sidney MT 59270
482-2723

Style
1 Level

Insulation
Ceiling - R95
Double Walls - R40
Floor - R19

Square Feet
1,480

Special Features
Triple-pane Windows
Superinsulation
Root Cellar
Earth Berm

Heat
Passive Solar, Electric Baseboard

Completed
September 1982

Bitter winter weather is no stranger to the exposed slope just south of Sidney where Hazel and Martin Wersland live. Despite the needle-like fangs of the cold season, the Werslands have a sort of "tropical Montana" inside their house, even in the worst weather.

The key to comfort in the Wersland house is insulation, and lots of it. The exterior walls are more than a foot thick, built with two 2 x 4 stud walls separated by a 6-inch space. The cavities in the stud walls are insulated with 3 1/2-inch fiberglass batts, with a layer of 6-inch batts installed in the space between the stud walls. The house is built over a crawl space, with 6-inch, foil-backed fiberglass batt insulation between the joists under the floor. The ceiling is insulated with 30 inches of blown-in fiberglass with an R-value of about 95. (DNRC building specialists suggest that the Werslands' ceiling probably has more insulation than it needs. At some point extra insulation stops being cost effective. R60 in the ceiling of a superinsulated house normally is considered sufficient.)

R-value of insulation in the outside walls is about 41. All windows are triple-glazed. A continuous polyethylene air-vapor barrier on the back of the inner stud wall and in the ceiling prevents movement of moisture.

Berm Turns Weather

The house is sheltered on the north side by an earth berm that deflects north

From the front, the Wersland house looks conventional.

An earth berm protects the north side of the Wersland house.

winds up and over the house. The living space is isolated from the berm by a 2-foot-wide passageway between the concrete retaining wall and the superinsulated rear wall. The house roof extends over this passageway, which runs the full length of the house. A door opens to the outside from each end of the passage. An 8 x 12 foot root cellar in the earth berm is reached from inside the house.

Ventilator Provides Good Air

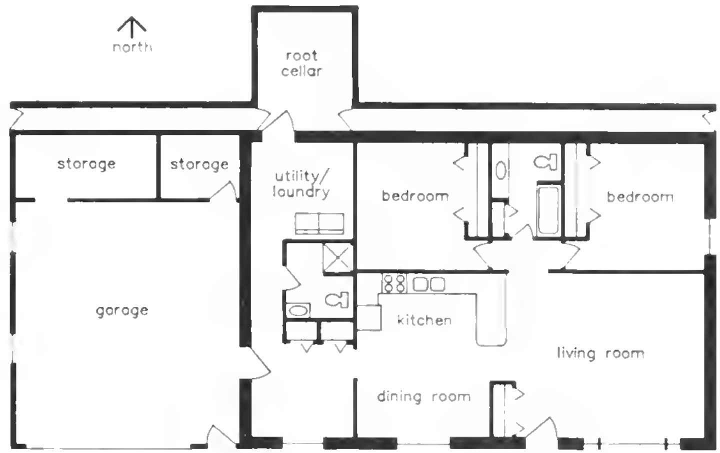
A VanEE 200 heat recovery ventilator provides easy control of indoor air quality in the house. The Werslands said the ventilator ran much more the first year they were in the house than it has since, because the building materials were in the process of drying out, which increased the humidity. The installed cost of the ventilator, including ducting, was about $1,200. The Werslands keep their humidistat set on 60 percent. If tobacco smoke or odors become a problem, the Werslands can freshen their air by manually turning on the ventilator fan.

Big Windows Welcome Sun

Large, south-facing windows let the winter sun in to provide solar heating, and also give the occupants a sweeping view up the Yellowstone valley to the southwest. The only heat the house needs to supplement the sun is provided by electric baseboard heaters that the Werslands bought for $83.

Jack Frost Gets Turned Away

Martin said that in the nearly six years they have lived in the house, the outdoor chill factor has dropped close to 50 below zero without creating any discomfort inside the house. On one occasion, the power went off for six hours when the outside temperature was 18 below, and the inside temperature of the house only dropped 4 degrees. The Werslands were gratified when their first-year heat bill was only $156, and they remain pleased that their bills have stayed in that range.



Sources of heat for the Wersland house: the sun, entering window at right, and $83 worth of electric baseboard heaters, one of which is at the far end of the room.

An Extra $2.50 Per Square Foot

The floor plan of the Wersland house is a standard, single-level design with approximately 1,480 square feet of floor space. Construction cost for a professional contractor to build a similar house would be about $62,000, or $42 per square foot, according to the builder, Ken Wersland, who operates Wersland Construction of Sidney and is the son of Hazel and Martin Wersland. Ken said the use of superinsulation construction methods adds approximately $2.50 per square foot to the cost of a house such as this one.

After nearly six years in their house, the Werslands have no fault to find with it. They can watch the blizzards roll by with never a draft nor a sound in the house. "We like it and our neighbors like it," Martin said. □

Berming Fends Off Wind, Preserves View

Owners
Richard and Irene Bottomly

Location
Sun River

Designer
Stephen L'Heureux, Architect
Bibler/L'Heureux Architects
320 1/2 Central Avenue, No. 17
Great Falls, MT 59401
771-0770

Builder
Gene Daniels
4017 Fifth Avenue South
Great Falls, MT 59401
453-1369

Style
1 Story

Insulation
Ceiling - R40
2 x 4 Wall - R25
Crawl Space Wall - R10

Square Feet
Main - 3,500

Special Features
Earth Sheltered
Clerestory Windows
Sunspace
Outside Combustion Air

Heat
Natural Gas, Wood

Completed
December 1985

Home builders along the Rocky Mountain Front face a major challenge in dealing with the rambunctious winds that roll down from the mountains. The blowing snow and bitter temperatures of winter and boiling dust of summer made Dick and Irene Bottomly consider building an underground house. Ultimately, however, they decided the costs of going underground were too great for the benefits. Their new house, just west of Sun River, meets the wind halfway, built as it is with earth berms up to the windowsills.

Out of the Wind

On the south side of the house, brick pillars distinguish a handsome portico which invites visitors out of harsh westerly winds and prevents snow and dust from blowing into the house with each opening of the door. "I was out here when we were planning the house," Dick said. "It was blowing like hell—dust everywhere. I decided right then to have a sheltered entryway."

Soil is banked 4 feet up the walls on each side of the entryway and around the ends of the house. The berming deflects the wind's force, directing it around and over the house, and the soil's tempering qualities buffer the house from cold and heat.

For structural stability, the lower 4 feet of the bermed walls are concrete. The concrete was waterproofed and drains were placed near the footings before the area next to the foundation was backfilled with soil. Inside the crawl space, the

A handsome entry with earth berming on each side shelters visitors from blowing snow or dust at Irene and Dick Bottomly's house. Clerestory windows and sunspace capture heat and light.

Berming on the west of the house deflects the winds rolling off the Rocky Mountain Front and buffers the house from cold and heat.

concrete walls are insulated with 2-inch extruded polystyrene down to the footings. A 6-mil polyethylene moisture barrier covers the ground in the crawl space.

The walls rising from the concrete are framed with 2 x 4 studs. The stud cavities are filled with foamed-in-place urethane insulation, which also serves as an air-vapor barrier. The ceiling is insulated with a 13-inch layer of fiberglass, and has a 6-mil polyethylene air-vapor barrier. Continuous soffit vents and a continuous ridge vent provide ventilation for the attic. Brick veneer, cedar trim, and vinyl-clad windows make the exterior easy to maintain.

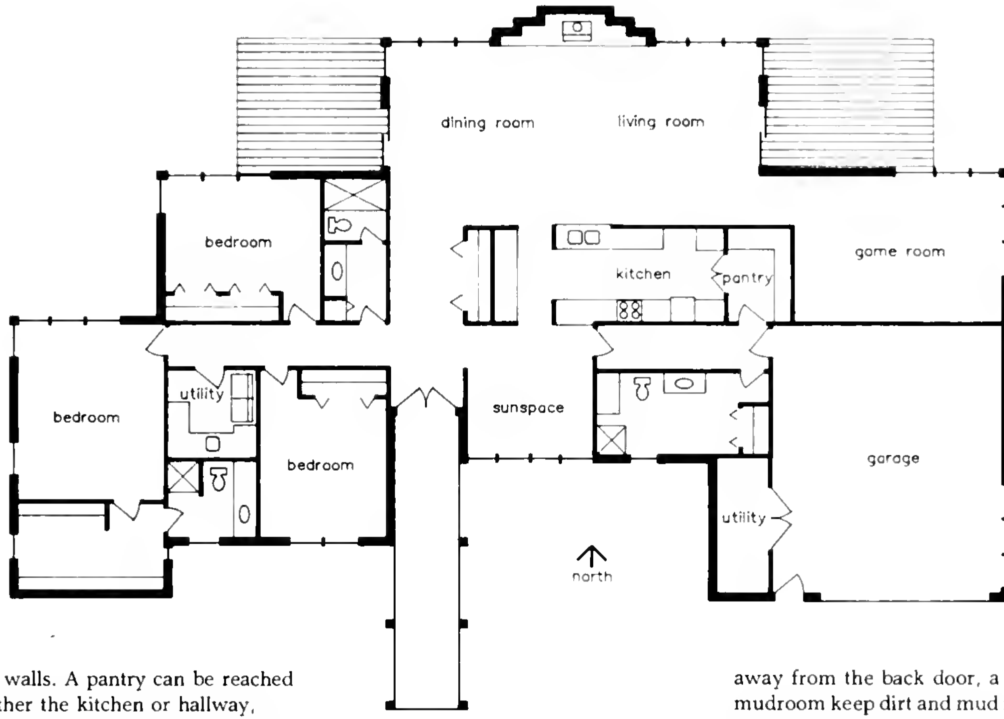
Insulated walls and overhead doors help keep the temperature in the attached garage above freezing. "We have a small heat vent in the garage which keeps it around 35 degrees even when it's minus 30 degrees outside," Dick said.

Light and Airy Rooms

Inside, plenty of windows open the spacious living area to panoramic views and ever-changing natural light. All windows are double-glazed Rockwell with low-E coating except the sloped windows in the sunspace.

Adjacent to the foyer and kitchen, the sunspace offers a cozy retreat for morning coffee as the sun pours through its windows. On the sloped glazing of the sunspace, the windows, from P.P.G. Industries, are made with solar bronze tinted glass, the same type used in cars. "They cut down on the light and really work well to keep the sunspace from overheating," Dick said. Levolor shades on all windows turn away excessive sunlight.

The abundance of light extends to the galley kitchen, where cutouts high on the interior south wall admit light and warmth from the adjacent sunspace. Lustrous cherrywood cabinets line the



kitchen walls. A pantry can be reached from either the kitchen or hallway, making it handy for groceries coming in from the car. "The pantry is wonderful," Irene said. "Besides being cheaper, it's more efficient than cabinetry. Everything is open so I can see it and get to it."

Down the hall in the spacious master bedroom, Irene pointed out the roomy walk-in closet with fluorescent lighting. The open shelves and clothing rods at different heights make it easy to get to clothing without the encumbrance of closet doors. Passing by the utility area adjacent to the bedrooms, Irene said, "the location is marvelous for saving me steps. Most of the laundry is generated back here."

Insulated French doors open to patios at each end of the house. "Those doors are good and tight," Irene said. "We don't have the drafts we did with the sliding doors in our other house."

Farm Life Considerations

Although Dick has a law practice in Great Falls, he also spends time tending cattle and crops near his Sun River house. The arrangement of the house accommodates the bulky clothes and dirt that go along with farming operations. An insulated door opens from the garage to a spacious hallway, which offers plenty of room for hanging work coveralls and wool jackets. A few steps away from the back door, a bath and mudroom keep dirt and mud from being tracked through the house.

Air Quality Influences Stove Choice

The living room's center of interest is the wood stove sitting on a raised hearth and flanked by richly grained oak shelves. The Bottomlys chose a wood stove over a fireplace because of concerns over indoor air quality. The airtight stove uses outside air for combustion, thus limiting any backdrafting problems in the tight house. Soapstone on the stove's sides and top adds mass for heat storage, with the warmed stone radiating heat several hours after the fire dies. Dick said the stove is big enough to completely heat

A south-facing sunspace and clerestory windows harvest the warmth of winter sun.

the house, but that they use gas heat as their main source. "I'm too lazy to go get our wood," he said with a laugh.

Gas Forced Air Furnace Heats House

The high-efficiency Amana gas furnace doubles as an on-demand hot water heater. For the coldest months last year, the gas bill averaged $55. Dick said that when they were building, they should have paid more attention to the operating principles of the furnace. "We designed a closet in the garage for it, then found the furnace had the heat discharge through its top. So we had to dig a 5-foot x 12-foot x 8-foot hole beneath the sunroom and put concrete in the bottom to hold the furnace. For the time and effort, we could have put in a small basement." Combustion air for the furnace is piped from the outside into the furnace. Returns in the ceiling draw the hot air from the top of the room through ducts back into the furnace to be recirculated through the house, thus reducing the heat stratification found in many high-ceiling houses.

Planning Pays Off

The Bottomlys are pleased with their house's layout and energy efficiency. "When you plan a house, you think and think about it, but you don't know if it will work until you live in it," Irene said. "We designed it with an eye for having a view in every direction and for every room to be light and airy, and we've accomplished that. Dick designed it to save energy and we are very happy with our low gas bills." □

White textured walls and a vaulted ceiling diffuse natural light evenly throughout the house. A pass-through window from kitchen to living room is convenient for serving and lets the cook visit with family or guests in the living room.

Bermed and Bright

At the end of a narrow road winding back into the pine-timbered hills near Superior, a small house uses the earth to help fend off winter's chill.

Juanita Cutler, the home's owner, said she had long been interested in bermed houses, but had a hard time finding one that suited her pocketbook and requirement for light. This one did. Constructed for approximately $25 per square foot, the house was easily affordable. And it is bright. Berming extends 2/3 up the north wall which allows room for a small window in each of the three bedrooms at the back of the house. "The windows eliminate the cave feeling I had when I was in other bermed houses," Juanita said. "Here, I can see daylight when I wake up in the morning."

The berming extends about a third of the way around the sides of the house, leaving space for an entry on the west side and a stairway down to the fruit room on the east side. On the upper roof, grass grows in 8 inches of soil. "I have to mow and water my roof periodically," Juanita said. "That's about the only upkeep I have." The lower front roof is graveled.

Eclectic Blend of Energy Features

John Torma, the builder and first occupant of the house described the construction. The post-and-beam framing technique eliminated the need for interior supporting walls, so bathroom and kitchen walls stop 1 foot short of the ceiling. This foot-high space provides pathways for heat circulation. Heat circulation is also promoted by rectangular openings cut high on the wall between the bedrooms and the living area.

The large bank of double-glazed clerestory and picture windows on the south is framed into 2 x 6 walls insulated with fiberglass. Although northwestern Montana doesn't get a lot of winter sunshine, Juanita said the solar gain is still considerable. "My floors and walls are never cold and I rarely shut my curtains. There just aren't any leaks from the windows. Of course, this is a sheltered site, with virtually no wind." An expansive overhang on the home's south side keeps hot summer sunshine out of the house and protects the deck running the length of the windows, a convenient perch for Juanita's Irish setter to keep an eye on the world.

Thick expanded polystyrene foam board insulation on the exterior of the concrete walls prevents loss of heat soaked up from the day's sunlight or from the circulating wood heater. At night, the walls radiate warmth back into the house.

Cedar siding and a sod roof, along with unobtrusive earth berming, clerestory windows tucked into a two-level roof, and big south-facing windows contribute to the comfort and rustic charm of Juanita Cutler's house.

Owner
Juanita Cutler

Location
Superior

Designer and Builder
John Torma
413 North Avenue East
Missoula MT 59801
728-0272

Style
1 Story

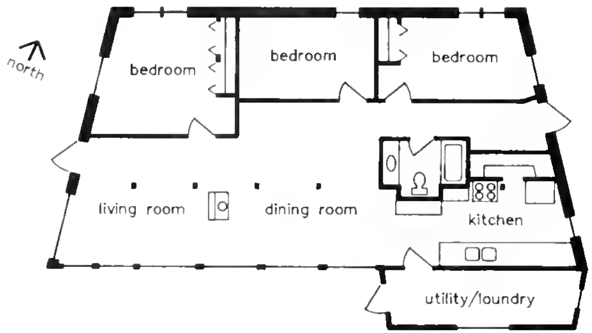
Insulation
Ceiling - R24
2 x 6 Wall - R19
Crawl Space Walls - R20

Square Feet
1,000

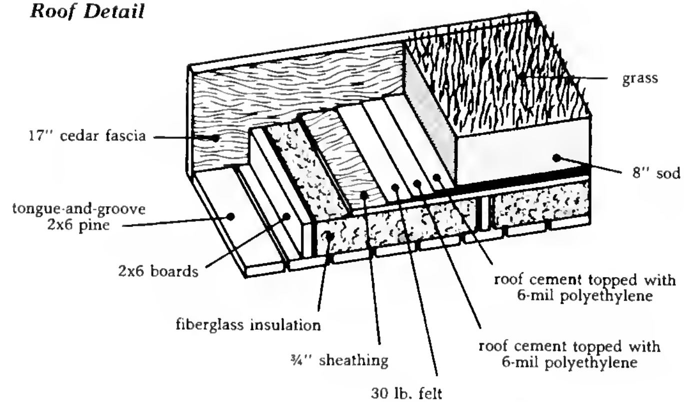
Special Features
Earth Sheltered
Sod Roof
Post and Beam
Composting Toilet
Economical

Heat
Solar Wood, Electric Baseboard

Completed
1979



Roof Detail



A multi-layered roof (see diagram) keeps moisture and cold from descending into the house. The chimney is 6-inch Metal-bestos with aluminum roofjack for flashing. The vent for the Clivus Multrum toilet is 12-inch Metal-bestos with fiberglass roofjack for flashing. The vents are sealed with multiple layers of roofing cement and 6-mil black plastic. John said one small leak around the toilet vent caused some water spots on the bathroom ceiling. The leak has been repaired. "Over the years I lived in the house, I used between 3 and 5 cords of wood a year," John said. "The more snow, the less wood because of the snow's tremendous insulating qualities on the sod roof."

The current owner echoed John's satisfaction. "I have no cold or drafty areas in the house," Juanita said. "During the day I let the fire in the wood heater burn down by 10 a.m. and don't start it again until 4 p.m. I shut it down at night when I go to bed. So far, there has never been a drop of more than 10 degrees overnight." Two small electric baseboard heaters are used only in the winter when she is going to be away for more than a couple of days.

Clivus for Composting

Downstairs, Juanita opened the door to the room containing a large holding tank for the waterless Clivus Multrum toilet. John and Juanita said the toilet, which turns wastes into compost, is one of the best conservation features of the house. "It really works," Juanita emphasized. There's never a problem with odors, and it's free of harmful bacteria. I pump out the liquids periodically and shovel the resulting compost out once a year and spread it around my ornamental shrubs."

Juanita pointed out that the composting process must be kept active; that's why the garbage disposal, which contributes organic material, is an important component of the system. A whisper-quiet fan in the Clivus Multrum continually aerates the waste. The residue in the tank looks like the dried compost available at the local garden store. Used water from the washer, shower, and sinks runs out to a seepage pit where it soaks into the ground.

John is happy with the performance of the house. The only design problem was an attached greenhouse, which John said caused high humidity and drastic temperature fluctuations from day to night. He turned the greenhouse into a utility area by replacing the glazing with insulation and siding. □

Clerestory windows invite the winter sun to warm and brighten the house.

The kitchen echoes the rustic theme, with handcrafted cabinets of pine and cedar, butcher-board countertops, and open shelves. The cabinet on the left contains the garbage disposal which empties into the tank serving the Clivus Multrum toilet.

Living in an Envelope of Air

Owners
Roger and Juanita Hearst

Location
Superior

Designer
Positive Technologies
P.O. Box 2356
Olympic Valley, CA 95730

Builder
LaVerne Schwartz
5821 Kerr Drive
Missoula, MT 59801
251-3816

Style
Envelope

Insulation
Ceiling - R50 above sunspace
R30 above bedrooms
Single Walls - R19
Double Wall - R39
Basement Wall - R14
Slab - R14

Square Feet
Upper - 766
Main - 1,184
Basement - 1,088

Special Features
Envelope Construction
Sunspace

Heat
Passive Solar, Wood, Electric

Completed
November 1981

Lying in bed watching the moonlit clouds drift across the sky, or sitting at the dining table watching elk meander through their yard are just two of the pleasures Roger and Juanita Hearst enjoy in their house near Superior. "The large windows let us watch the wildlife from our living area," Roger said. "During hunting season last year we had five cow elk in our yard. We see deer and coyote all the time."

In the timbered hills west of Superior, Roger and Juanita's house is an adaptation of Bruce McCallum's envelope plan. (For construction details, see the related article on page 147.) "We wanted an energy-efficient house," Roger said, "so we talked to the Mineral County extension agent about it. He put us in touch with Bruce."

The Hearsts modified McCallum's floor plan to include a basement under the main living space and a crawl space beneath the sunspace. They installed a Montana-made Arlee wood stove in the basement instead of a Russian furnace.

Metal Roof

To minimize maintenance and leaks, Roger installed a metal roof on the house. Its construction from the inside out is 3/8-inch plywood, covered with 2 inches of rigid foam insulation. This is overlaid with 1/2-inch plywood, then a framework of 1 x 4s to maintain a 1-inch airspace under the metal roofing. The strips of ASC Pacific Zincalume roofing are 30 feet long and each extends without a break from top to bottom of the roof.

The sunspace on the south side of Roger and Juanita Hearst's house is an important component in their heating system.

Sunspace Harvests Heat

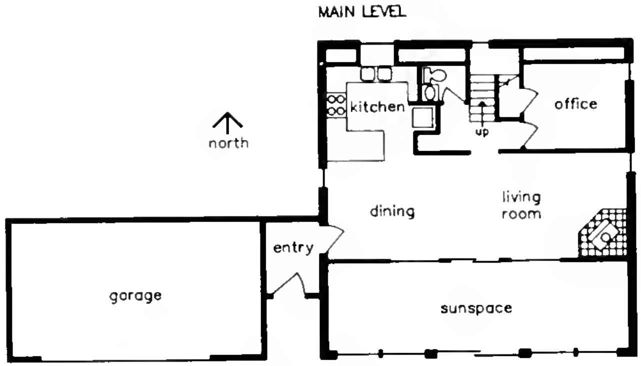
Like McCallum's house, the south side of the Hearst house is given over to a two-story sunspace. The sunspace opens to the living room on the first floor and the master bedroom on the second floor. The second-story windows are set at a slight angle.

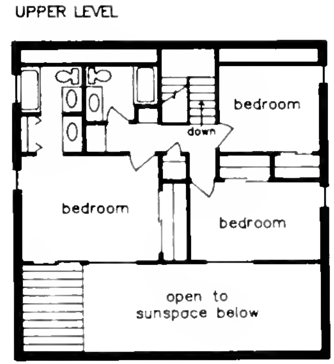
"I like the slanted windows," Roger said. "I don't think we'd have the view with vertical windows. Those five windows were a chore to install, though;

they're double glazed and weigh 300 pounds apiece." Juanita remarked that rain and snow do a surprisingly good job of keeping the windows clean. "I wash them just once a year in the spring," she said.

The sunspace is also an integral part of the home's solar heating system, warming air which rises to the attic plenum, and then moves down through the inner wall space on the north side of the house, into the basement, through the crawl space, and back up to the sunspace.

Heat from the air entering the basement is absorbed by the 8-inch concrete walls. Two inches of extruded polystyrene on the outside of the concrete prevent the heat from escaping. Roger placed his hand against the wall. "Once these walls are warm, it's easy to keep the house at a comfortable temperature."





Vents Allow Natural Cooling

In the summer the home is cooled by a combination of vents on the north side and in the sunspace. Roger said that when it's 85 to 90 degrees outside, the inside can be cooled to the point that a long-sleeved shirt or sweater is called for.

Wood and Electricity Augment Solar

When the stove is in use, a fan above it circulates warm air in the basement. Fans at each end of the sunspace draw air from the basement through the crawlspace and into the sunspace. "This is the fifth heating season," Roger said, "and we burn a maximum of three cords of wood a year."

Besides heat from the sun and the wood stove, electric baseboard heaters kick in for about four hours a day, mostly when the Hearsts leave for periods of a few days during the winter. Roger said they use between 17,500 and 19,000 kilowatt-hours annually. At a rate of $0.0485 per kWh, that translates to between $848 and $921 a year. He attributes about a third of the cost to heating, the rest for pumping water from the well, cooking, lighting, and heating water. A water heater insulating blanket minimizes heat loss from the tank.

Besides collecting the sun's heat, the sunspace allows room for growing plants. A sliding door links the master bedroom on the second floor to a corner of the deck overlooking the sunspace.

The Hearsts are kept home most of the time by their business of operating a nursery of shade and fruit trees. They keep the house comfortable at 68 degrees. "When the sun shines, we don't even have to fire up the stove," Roger said.

To reduce heat loss to the outside, Juanita made insulated curtains to keep warmth in on the coldest nights. Roger said that in January 1986 when it was -10 degrees outside, it was 90 degrees in the sunspace. During the coldest night at -20 degrees, the sunspace temperature only dropped to 47 degrees without auxiliary wood or electric heat.

House Pleases

The Hearsts did most of the construction themselves, and don't know how much it would cost to have a contractor build a similar house from scratch. Roger said the tax assessor appraised it at $60,000.

Is there anything the Hearsts would do differently? "Yes. I wouldn't put wallpaper over oil-based paint; it'll peel off," Juanita said, chuckling. "As far as the construction of the house, no."

Roger's enthusiasm is contagious. "We enjoy this house," he exclaimed, taking in the room with a wave of his arm. "It looks different as you drive up to it, but on the inside, it's just an ordinary house. An extremely comfortable one though."

Superinsulation with a Difference

Owners
David and Kay Nelson

Location
Turah

Designer
Owners

Builder
Roger Fangsrud
706 Gary Drive
Missoula, MT 59801
549-5484

Style
1 Story with Basement

Insulation
Ceiling - R60
Double Walls - R45
Under Slab Perimeter - R15
Under Remainder of Slab - R7.5

Square Feet
Main - 1,408
Basement - 1,408

Special Features
RCDP Construction
Superinsulation
Blown-in-blanket Insulation
Advanced Drywall Approach

Heat
Passive Solar, Electric Baseboard

Completed
September 1986

People interested in energy-efficient housing generally agree that superinsulation is a good idea, but not everybody agrees on how to best apply this technology. The double stud wall with three layers of fiberglass batts is common enough to almost be considered standard superinsulation practice, but some builders prefer other methods. Roger Fangsrud of Missoula is one builder who does things a little differently. One example of his work is the house he built for David and Kay Nelson in the pines east of Missoula near Turah.

Kay and David Nelson's superinsulated house sits among the pines near Turah, east of Missoula.

Nothing Different on the Outside

The outward appearance of the Nelson house is not substantially different from many other single-level houses with daylight basement. Inside the walls, however, things are not the same. The difference is not with the double 2 x 4 stud wall construction style; this is the usual configuration with studs on 16-inch centers, offset so most of the studs in the two walls are not directly opposite each other. The main variation is the insulation in the outer stud wall, which is blown-in fiberglass to which resin has been added. The resin makes the fiberglass sticky and keeps it from settling in the walls. Netting is used to hold the blown-in insulation inside the stud wall cavities. Insulation of this type (referred to as "blown-in blanket" or "BIBS") is denser than standard fiberglass batts and has a higher R-value, about R4 per inch, contrasted to a maximum of approximately R3.6 per inch for standard fiberglass batts.

A Thorough Insulation Scheme

Standard fiberglass batts were placed horizontally to fill the 6-inch space between the two stud walls. Ordinary 3 1/2-inch batts were installed in the inner stud wall. The above-grade portion of the basement wall is slightly different than the outer wall on the main floor. This portion of the basement wall also is a double stud wall, but the outer stud wall is 2 x 6s on 16-inch centers. The inner stud wall on the basement level is 2 x 4s on 16-inch centers, with a 3 1/2-inch space between the inner and outer walls.

The cavities in the 2 x 6 portion of the wall are insulated with the blown-in fiberglass blanket. The inner wall and the cavity between the inner and outer walls are insulated with 3 1/2-inch fiberglass batts. Both the above-grade basement walls and the main floor walls are insulated to R-45. The inner 2 x 4 stud wall in the basement extends below grade to the footing. The concrete portion of the basement wall is insulated on the interior with 1-inch extruded polystyrene foam boards next to the concrete, and with 3 1/2 inch fiberglass batts in the stud wall

over the foam. Total R-value in this part of the basement wall is 16. The ceiling is insulated with 21 inches of blown-in fiberglass with an R-value of 60.

The outer 2 feet of the basement floor slab is insulated with a 3-inch layer of extruded polystyrene foam board over 4 inches of sand. Inward from this 3-inch insulation, the slab is insulated with 1 1/2 inches of the foam board. A Tu-Tuff moisture barrier was placed between the foam and the 4-inch slab.

Advanced Drywall Construction

One other variation from standard practice is the use of vapor-barrier paint as the air-vapor barrier, rather than the usual polyethylene sheet. This paint is used in conjunction with advanced drywall construction techniques (see Glossary).

Windows are Clawsen low-E double pane. Outside doors are Acorn metal doors with foam core, R-15. Except for some solar gain through south-facing windows, the only source of heat for the Nelson house is electric baseboard heaters. "I'd use gas if I could get it," David said, noting the lower price of gas heat. The Nelsons have lived in their house since September, 1986, and the highest monthly heat bill in their first year was $35.

Thick, heavily insulated walls and multi-pane south-facing windows are keys to energy efficiency

The Owners' Own Design

David said he designed the house himself, with some inspiration from Buffalo Homes and Better Homes and Gardens Magazine, and got an architect to draw the plans. Cost to build the house was $57,000. Floor space is 1,408 on the main floor with an equal space in the finished basement. The Nelson house thus cost about $20 per square foot. Costs were driven up to some extent by the need for a heat recovery ventilator to maintain air quality in the house. The VanEE ventilator and duct work cost about $2,500 to purchase and install, David said.

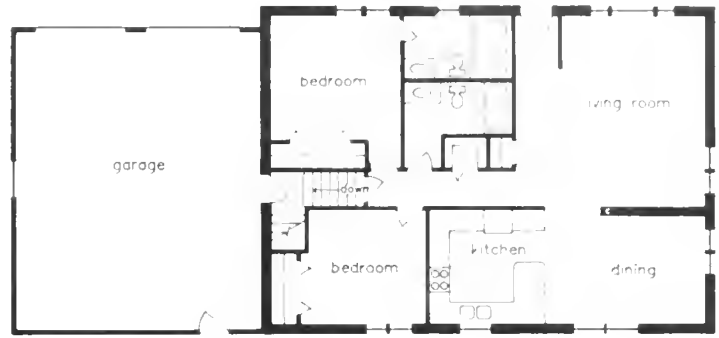
Bonuses, Expected and Unexpected

So far, the Nelsons say they are happy with their house, and can't think of anything they would do differently if they were building again. One bonus in the house has been its cleanliness, Kay said. In the house they lived in before, they used wood for heating, which made it hard to keep the house clean. In the new house, Kay said, "I only need to do a little dusting about every three months." "We're glad to be off wood," David said.

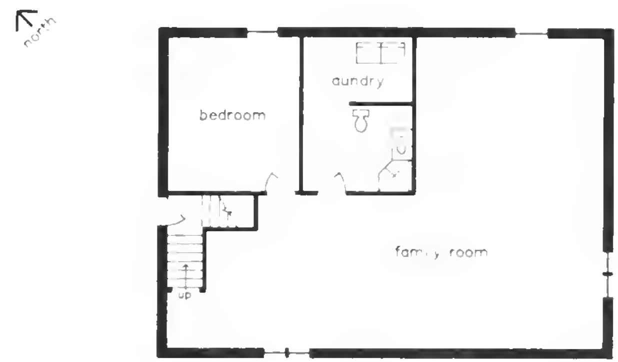
Conventional Thinking Hinders Energy Efficiency

The Nelsons said the main obstacle in building a superinsulated house was finding a builder who was interested in building a house that required any deviation from the old standard construction practices. Superinsulation, though gradually becoming more popular, is still far from routine.

Except for Roger Fangsrud, David said, "We couldn't find anyone who was interested in building a custom, energy-efficient house." ☐



MAIN LEVEL



BASEMENT

No Shortage of Plans

Owners
Fred and Dana Beyer

Location
Ulm

Designer
Owners and Builder

Builder
Larry Berg
Rural Route 1206
102 Windsor Lane
Great Falls, MT 59401
965-3860

Style
Split Level with Basement

Insulation
Ceiling - R52
Walls - R24
Foundation Walls - R16

Square Feet
Main - 1,550
Basement - 1,425

Special Features
Solarium

Heat
Electric Baseboard

Completed
November 1986

People considering building an energy-efficient house will discover no shortage of architectural plans for such structures. Fred and Dana Beyer of Ulm looked at 400 plans when they were deciding on the features they wanted in the new house they were planning to build. Rather than adopt any of these designs outright, they took the features they liked and combined them into a whole new plan of their own. The Beyers are a young family with two children under 12, and they knew they wanted a spacious house that would be easy to keep warm.

One Story, Full Basement

The house the Beyers built is one story with a full daylight basement. The main floor has 1,550 square feet of floor space, with another 1,425 in the basement. The outside walls are single 2 x 6 stud walls with the studs on 16-inch centers, braced with diagonal metal wind braces rather than the standard plywood sheathing. Insulation in the walls is 6-inch, unfaced fiberglass batts, with 1-inch tongue-and-groove extruded polystyrene boards attached directly to the outside of the studs under the 1-inch cedar-channel siding. A 4-mil Visqueen air-vapor barrier was installed under the half-inch drywall. R-Value of the insulation in the exterior walls is about R24. The concrete basement walls are insulated on the outside with an inch of extruded polystyrene, and on the inner side with 3 1/2 inches of faced fiberglass batts in a 2 x 4 stud wall next to the concrete.

The Beyer house is handsome and economical to heat. Note solarium at right.

The ceiling is insulated to about R-52 with 20 inches of blown-in fiberglass over 5/8-inch drywall. The Beyers did not install an air-vapor barrier in the ceiling. Fred said they wanted to keep their costs down by not installing a heat recovery ventilator, and he feared the lack of a ventilator would cause moisture problems if the ceiling had an air-vapor barrier. He said a heat recovery ventilator would have added as much as $2,000 to the cost of the house.(DNRC building specialists suggest that it is often unwise to eliminate the air-vapor barrier in the ceiling. The absence of the barrier can cause moisture problems that may not be readily seen, and the house still needs to be ventilated in one way or another. See the section on "Controlled Ventilation" in the Introduction.)

Solarium Brightens, Warms House

One of the main features of the house is the 10 x 12 solarium. This solarium collects sunlight to help warm the house and provides a comfortable, well-lit addition to the main floor. This solarium was at ground level in the original plan, but the Beyers decided to elevate it to the level of the main floor. The additional elevation gives a more commanding view of the surroundings, which include Square Butte to the west and the Missouri River and Big Belt Mountains to the east and south.

Minding the Thermostats

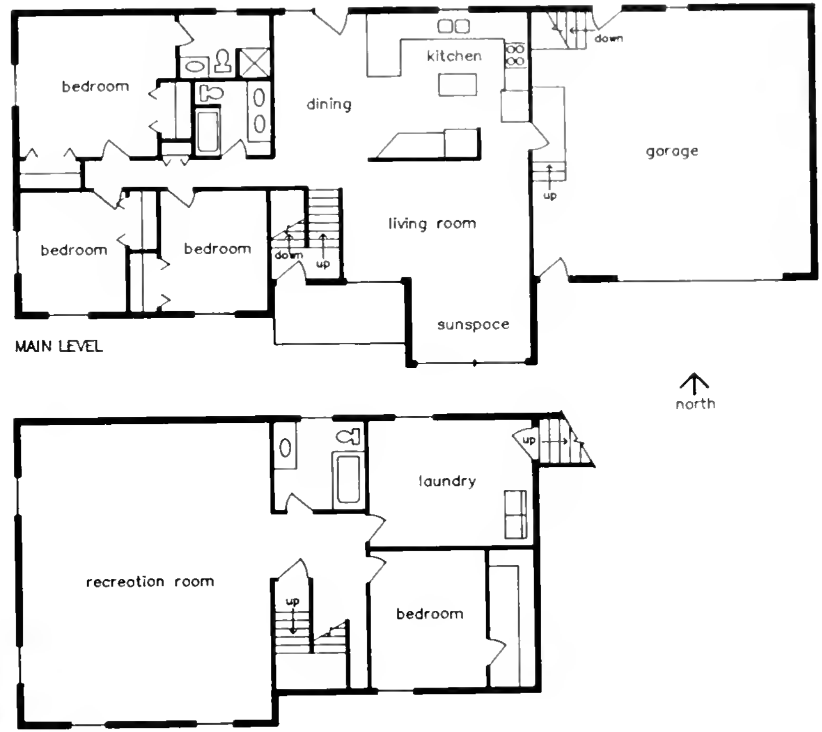
Solar energy collected by the solarium heats the whole main floor on sunny days, even when outside temperatures are low. Electric baseboard heaters supplement the solar gain. The Beyers keep their heat bills to a minimum by heating individual rooms only as needed. For example, Fred and Dana like their bedroom cool, so they never turn on the baseboard heaters there. "The master bedroom is heated with our electric blanket," Fred said. The kids' two bedrooms are heated only about eight hours a day. The living area is kept about 72 degrees during the day, and reduced to 68 degrees at night. All this caretaking with the thermostats pays off: the Beyers' monthly heating bills for the first four months of 1987, for example, averaged approximately $30. The highest bill in that period was $38, for January.

Attention to Detail Saves Energy Too

As part of their overall energy-conservation effort, the Beyers paid attention to small details along with the major considerations. For example, they installed foam gaskets behind all outlets and light switches, to eliminate possible air leaks. All hot water pipes are insulated, and the water heater has an R7 blanket wrap. Most lighting is fluorescent.

Long Side to the South

The long axis of the house runs east and west. This presents a long side to the south which maximizes the opportunity for passive solar heating through windows. The house has sizable windows for solar collection on the south side, and only small windows to minimize heat loss on the north side. All windows are Pozzi double pane, with low-E glass. South-side windows have pleated, metallic-backed shades that can be drawn to keep out excessive sunlight. Outside entry doors are Stanley insulated metal.



The solarium is a bright, warm place on the main floor of the Beyer house.

Energy Efficiency Boosts the Tab

Fred said the addition of extra insulation and other energy-efficient features probably increased the price of the house about 10 percent above what it would have been for a similar house built to outdated standards, such as single 2 x 4 walls and single-pane windows. The Beyers did much of the work on the house themselves, which allowed them to keep the price to about $70,000.

They Would Not do a Thing Differently

Dana said, "We are extremely happy with our house and wouldn't do a thing differently if we were building it over." Fred works for the Montana Power Company where he does residential and commercial energy audits for MPC customers. "I recommend what energy-efficiency measures MPC customers should use, so when we built our house, we decided to practice what I preach," he said. □

Sun-splashed Living

Owners
Jerry and Shirley Hayes

Location
Victor

Designers
Owners and Builder

Heating System Retrofit
Frank Pawarski
Pyro Tech
P.O. Box 8236
Missoula, MT 59807
543-3976

Builder
Roger King
2060 M. Bear Creek Road
Victor, MT 59875
642-3597

Style
1 1/2 Story

Insulation
Ceiling - R44
North and West Walls - R44
South and East Walls - R22
Crawl Space - R14

Square Feet
Loft - 600
Main - 1,900

Special Features
Heating System
Insulated Blinds

Heat
Passive Solar, Wood, Electric Baseboard

Completed
1981; Heat Retrofit—1986

After living in a barn without running water for a year while they built their house, Jerry and Shirley Hayes appreciate the amenities afforded by their energy-efficient home. "We live in every part of it," Shirley said.

The focus of the home is the two-story living room. Its south-facing window wall welcomes in the sunlight. Insulated vertical shades cover the double-glazed windows to control the amount of light entering or to reduce heat loss at night. "The shades work tremendously well and hang beautifully within the sills and window casings," Shirley said. "The house stays warm in the winter and cool in the summer."

Paddle fans in the living room, kitchen, and master bedroom circulate warm air from the high ceiling in the winter and waft cool breezes through the house in the summer. "If we had it to do over, we would install a second living room ceiling fan," Jerry said.

A loft provides space for a library, sewing nook, and office. Beneath the loft, a stone fireplace forms part of the living room's back wall, its beauty outweighed only by its utility.

"We were using the fireplace to preheat our hot water," Shirley said. "The temperature of the water often got high enough to trigger the pressure relief valve on the hot water tank, so in 1986 we decided to tap into the extra heat for the sunspace and the hot tub that sits in the sunspace."

On the southwest end of the Hayes house, a wall slopes from ground to roof, harboring a sunny plant-filled space. The slanted windows and orientation of the house at 10 degrees east of south afford optimum solar heating of the sunspace and hot tub water. When clouds obscure the sun or night falls, the specially designed fireplace heating system takes over the heating job.

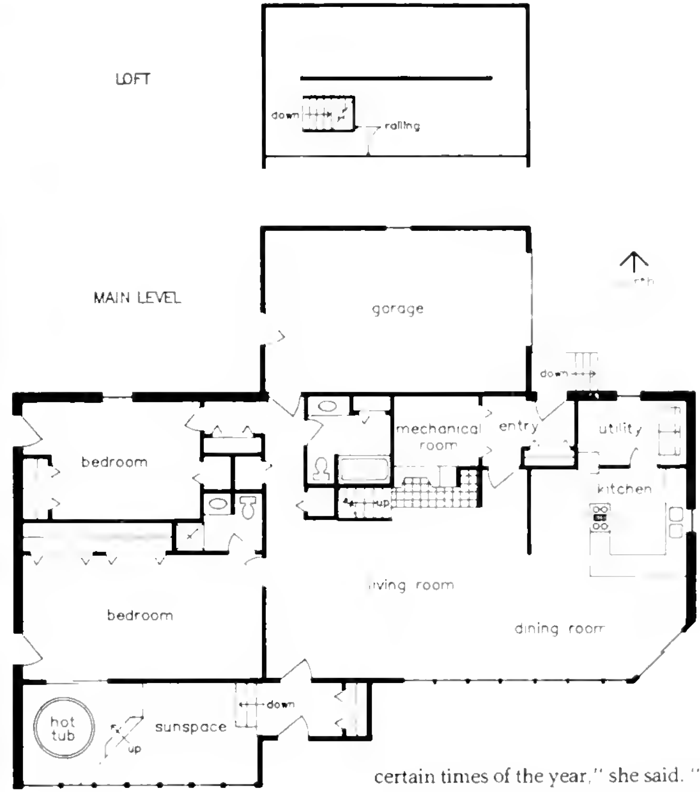
Wood-fired Hot Water Heat

Here's how it works. When a fire is burning, pumps continually circulate water from the hot water tank through steel box tubing at the top of the fireplace near the flue. The heated water travels from the fireplace through a heat exchanger. As the heated water winds its way through the heat exchanger, it gives up some heat to a glycol-water solution circulating through polybutylene pipes. The pipes run through the floor of the sunspace, and through a second heat exchanger located beneath the hot tub, delivering heat both to the sunspace floor and to the hot tub. The water travels from the heat exchanger to the hot water tank. A valve prevents the reverse flow of water from the hot water tank to the exchanger when no fire is burning.

Foam Panels for Sunspace Windows

When the fireplace isn't being used, an electric spa heater keeps the hot tub

Behind the hot tub (shown just below the small window), a sliding glass door opens to admit heat to the master bedroom. A door at the other end of the sunspace allows heat to flow into the living area.



warm. The cost of operating this backup last year was $53. To prevent precious heat from escaping through windows on chilly nights, 2-inch foam panels are pressed tightly into the window openings. "The room stays a constant 60 degrees even on the coldest nights," Shirley noted, "and we keep the tub at a minimum 84 degrees."

For others contemplating a sunspace, Shirley suggested they might want to use vertical instead of slanted windows. "The slanted windows let in too much heat at certain times of the year," she said. "And we had trouble finding covers for them. Although the foam panels are easy to pop in, they do take some time."

Energy-saving Construction

Heavy insulation and an air-vapor barrier preserve warmth and stop drafts. Double walls on the north and west are packed with a 12-inch layer of blown-in cellulose. Walls on the south and east are built of 2 x 6 studs with cellulose in the stud cavity. The ceiling has 12 inches of cellulose insulation. To insulate the crawl space, a thick mixture of cellulose and

glue was sprayed over the inside foundation walls. The house is further protected by 6-mil polyethylene in the walls and ceiling.

"Last year we burned 3 1/2 cords of slabwood and 3 cords of lodgepole and fir for a total cost of about $200," Jerry noted. Electric baseboards serve as back-up heat, but they aren't used much. Their annual electricity bill for everything, including the hot tub, runs around $450.

Other Options On Hold

Options for other energy-efficient features are in place but not in use as yet. "We put in a foundation footing for a Trombe wall, but decided the wall would block the view," Jerry said. "So far we feel we can do without it." During construction, the exterior sunspace wall was plumbed to accommodate solar panels on the roof. They figure they'll add the panels someday.

A Philosophy of Living

Jerry and Shirley designed their house around their philosophy of using renewable energy to save resources. "I've always studied alternative energy," Shirley said. "My brother in Helena heats his water and house partially with solar. So does my brother in Denver. In fact," she said, "we have all the DNRC energy books and we used them in building this place."

They are both retired now and have time to enjoy their home and the acreage they share with moose, deer, elk, coyotes, and a host of feathered friends. Their concern for the resources extends to not using chemicals on the lawn and garden. We want to protect the wildlife from contamination," Jerry said. □

Sunlight streams into the living room and loft through two-story high windows. The open floor plan promotes circulation of the warmed air.

Super Good Cents Log House

Nothing seems more Montanan than a sturdy log house against a snowy field, blue sky, and tall mountains. Solid as log homes are, many wouldn't win awards for energy efficiency. Nevertheless, Scott Wurster's log house in the Bitterroot overcame the inherent insulating inefficiency of log walls to qualify for the Super Good Cents award from Ravalli County Electric Cooperative.

Breezes Don't Penetrate

To meet Super Good Cents standards for Montana's climate, a house must be heated for less than 3.2 kilowatt-hours (kWh) per square foot per year. For Scott's 2,000-square-foot house, this means an annual space heating of no more than 6,400 kWh. Several steps were taken to meet this criterion. One step was achieving a low air change per hour to stop heat loss. "Air changes per hour" is the number of times the air inside a house is replaced by air from the outside through natural air leakage.

Finding the best way to stop the drafts took some research by Scott, builder Wendell Kenney, and personnel at the electric cooperative. A combination of a heavily insulated ceiling, tightly insulated crawl space, insulated windows, top quality logs, and an innovative chinking product did the job. A recent blower door test estimated the air change at one-tenth per hour.

A heat recovery ventilator brings in fresh air and exhausts the stale.

Heavy insulation in the ceiling, air-tightness, and a water-coupled heat pump combined to qualify this log house for the Super Good Cents award from Bonneville Power Administration.

Heat Pump Recovers More Heat Than it Uses

Another big step towards meeting the Super Good Cents standard was the use of highly efficient heating equipment. Scott chose a water-coupled heat pump. The unit extracts heat from 52-degree well water to provide radiant floor heating, to heat domestic water, and periodically to fill a hot tub. "The coefficient of performance (COP) for the Tetco heat pump is 3.50," Scott said. This means that for every kilowatt of electricity the heat pump uses to operate, it recovers energy equal to 3.5 kilowatts.

From a well, 52-degree water is pumped through a heat exchanger called an evaporator. The "warmth" from the water is absorbed by a liquid with a low boiling point flowing in the opposite direction. The heat causes the liquid to boil and change to vapor. The vapor travels to a compressor which squeezes the vapor, raising its temperature. The hot pressurized vapor is pumped to a second heat exchanger called a condenser where the vapor gives up heat to water circulating through pipes in the floor of the house, or to water for domestic use. Upon cooling, the vapor changes back into a liquid, is depressurized, and flows back to the evaporator to pick up more heat from incoming well water. The cooled well water flows to a drain field.

Owner
Scott Wurster

Location
Victor

Designer
Owner and Alpine Log Homes
118 Main Street
Victor, MT 59875
642-3451

Builder
Bear Construction
Box 48
Hamilton, MT 59840
642-3896

Style
Log 1 1/2-Story

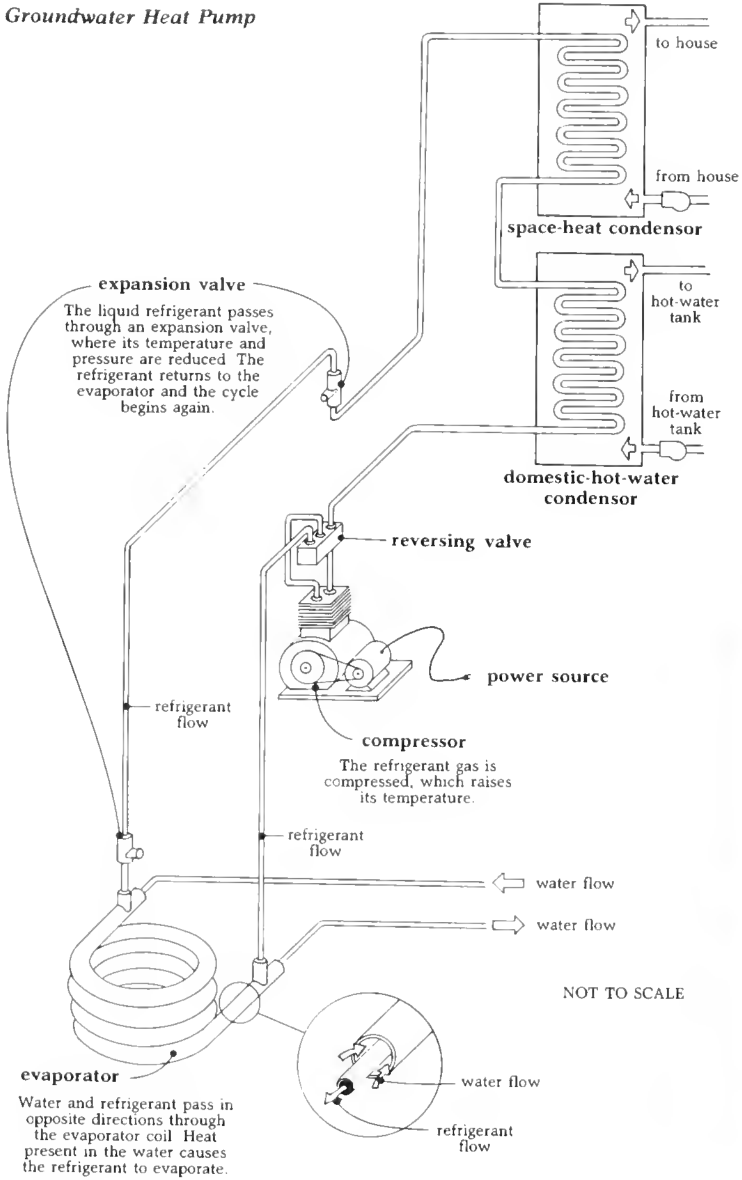
Insulation
Ceiling - R58
Walls - R8-9
Crawl Space - R20
Slab - R20

Square Feet
Loft - 240
Main - 864
Guest - 240

Special Features
Super Good Cents Construction

Heat
Electric Groundwater Heat Pump

Completed
November 1986



"The water is returned to the ground at 32 degrees, so 20 degrees of heat have been extracted from it by the heat pump," Scott said.

The heat pump and hot water tank are installed in the 4-foot-high insulated crawl space so any heat lost from them helps to heat the house.

Rudy Kratofil, Conservation Supervisor at Ravalli County Electric Cooperative, said the projected heating load for the log house is 12,376 kilowatt-hours annually. Because the groundwater heat pump is so efficient, however, it requires only 3,536 kWh of electricity to produce the 12,376 kWh needed for heating, or about 2 kWh per square foot per year—less than the Super Good Cents standard of 3.2. At 4 1/2 cents per kWh, the annual heat bill should run around $160.

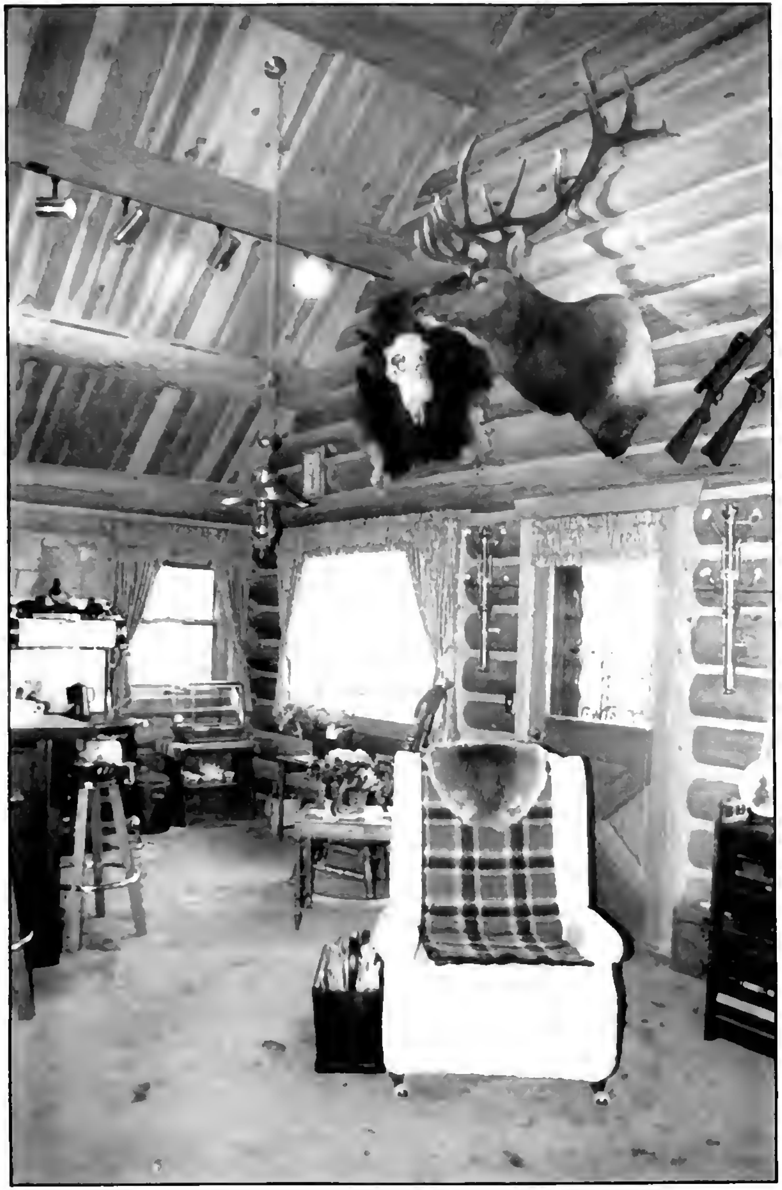
The heat pump has also eliminated the need for filters or chemicals to keep clean water in the hot tub. "It costs 50 cents to fill the 130-gallon tub with 105-degree water from the heat pump, and maintain that temperature for an hour," Scott said. "I simply fill the tub with fresh, clean water each time I use it. When the tub drains, the pipes do too so there's no danger of freezing."

The efficiency advantage of a groundwater heat pump comes at a higher initial cost than many heating systems. The heat pump unit itself is considerably more expensive than a furnace, baseboard heaters, or ceiling panels. A groundwater heat pump also requires a large volume of water that has a stable temperature year-round.

A Matter of Quality

"Meeting the Super Good Cents criteria was a matter of quality construction—no magic tricks," Scott said. "The house took

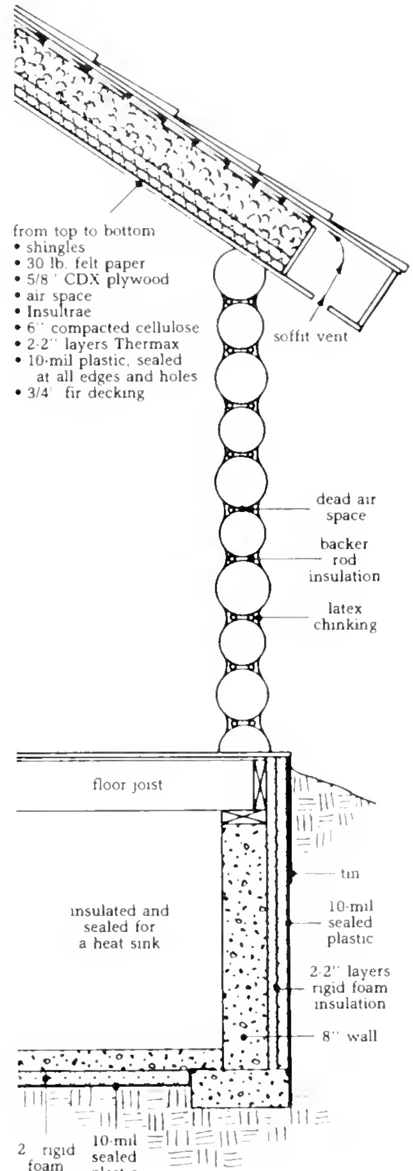
Quality craftsmanship is evident in the hand-pegged wood floors, cherry-wood cabinets, and brass fixtures throughout the house.



longer to build than the 'average' log house, and was about twice as expensive." Scott enumerated the components which resulted in the house's energy efficiency:

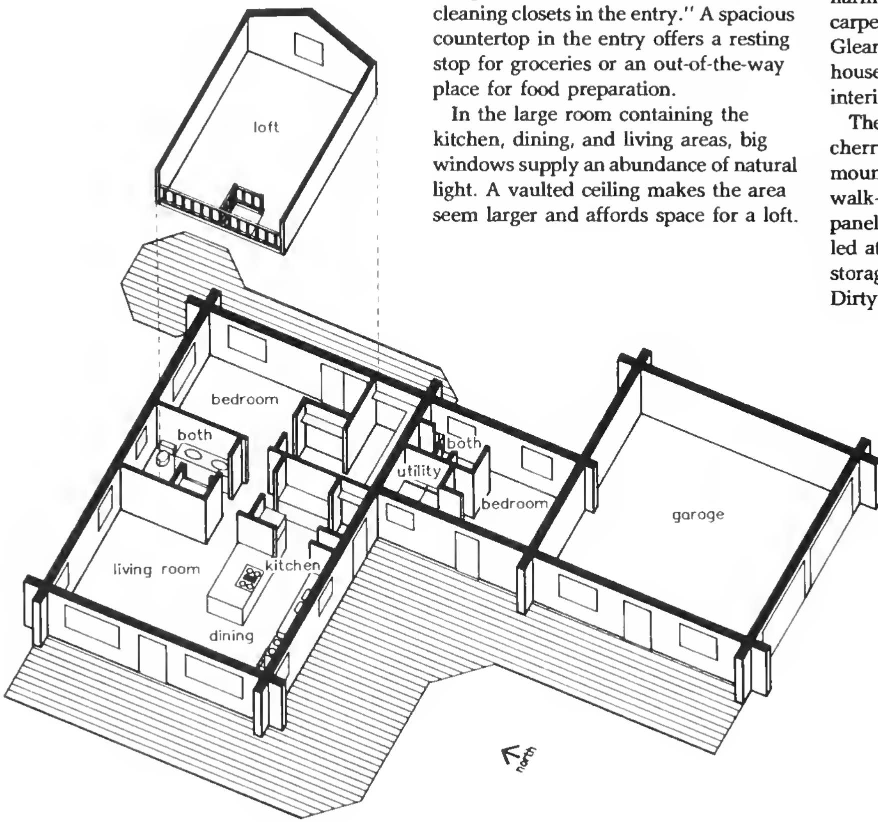
—10-inch-thick lodgepole pine logs
—insulated backer rod of closed cell foam under chinking
—polybutyl-based chinking between logs and in the gaps around door and window framing
—ceiling insulated with 4-inch Thermax and 8-inch blown-in cellulose
—good ventilation from Insultray vents above the insulation, soffit vents 2 feet on center, and a continuous ridge vent
—a 10-mil polyethylene vapor barrier in the ceiling
—4-inch-thick extruded polystyrene foam board insulation on crawl space walls and under the crawl space slab
—10-mil polyethylene moisture barrier under the crawlspace slab insulation
—Insul-Sun double-glazed windows with low-E film, plus exterior storm windows and doors
—a VanEE-2000 heat recovery ventilator.

Wall Section and Crawlspace Detail



Above the vaulted ceiling, thick insulation and good ventilation contribute to the house's energy efficiency.

A major factor in reducing drafts was the chinking material. "Polybutyl-based chinking is flexible and doesn't pull away when the logs expand and contract," Scott said. "I also took particular care to minimize formaldehyde problems by not using any particleboard or plywood on the interior. I can't over emphasize the importance of quality materials and workmanship to produce a house like mine," Scott said.



Built for Convenience

The house is as convenient as it is energy saving. Visitors have their own private quarters nestled between the garage and house. An adjacent utility area is out of sight around a corner, and a loft over the utility area adds extra sleeping space.

A large entry hall leads from the deck to the kitchen or the central hall. "I wanted to remove clutter from the kitchen," Scott said, "so I put the refrigerator, trash compactor, extra microwave oven, and cleaning closets in the entry." A spacious countertop in the entry offers a resting stop for groceries or an out-of-the-way place for food preparation.

In the large room containing the kitchen, dining, and living areas, big windows supply an abundance of natural light. A vaulted ceiling makes the area seem larger and affords space for a loft.

Craftsmanship Adds to Charm

Meticulous craftsmanship is visible throughout the house. Fir paneling on the partition walls is precisely cut to fit snugly against the log walls. In the galley kitchen, a floor of oak planks, hand laid and fastened with walnut pegs underscores lustrous cherry-wood cabinets. A wood-burning range lends its turn-of-the-century charm to the decor. The range sits on a blue-gray stone base that harmonizes with the dark steel-blue carpeting of the adjacent living area. Gleaming brass fixtures throughout the house add elegance to the warm wood interior.

The main bath is decorated with solid cherry-wood cabinets and dark blue tile mounted in gray-blue grouting. A large walk-in closet off the master bedroom is paneled with aromatic cedar. Rods installed at different heights provide compact storage for clothing of different lengths. Dirty clothes can be pushed through a small opening in the closet wall to the utility room on the other side. Antique brass mail boxes built into the bedroom wall for storage add a touch of whimsy.

Expansive decks on the east and west side of the house offer a choice of sunny or shaded lounging. A miniature log house perched on the rear deck railing is home for wrens. In the yard, three small log houses protect two wells and a septic tank. "The roofs can be lifted off and the walls removed to gain access for cleaning or maintenance," Scott said.

An Idyllic Retreat

The house sits in the middle of 153 acres containing a channel of the Bitterroot River. Flocks of geese and ducks take advantage of a network of ponds and dikes. Pheasants and grouse are common, and the streams are full of brown and rainbow trout. "This is a mini-reserve," Scott said, "a place where the wild creatures can have their young without being molested." He prohibits hunting and fishing, and raises wheat to supplement the animals' diet of native plants.

Motivation for Award

Why did Scott take the extra steps to qualify for the Super Good Cents award? "I wanted to build a log house second to none in terms of quality—a home that would be practical and comfortable for years to come," Scott said. "Also, the challenge of being the first to build a log house that would meet Super Good Cents criteria was a prime reason. And home values and marketability are becoming ever more related to their energy efficiency." ◻

Solar Log Home for Snowy Winters

Near the old gold mining town of Virginia City, Montana's winter sun provides most of the heat for Stephanie Wood's log house. "Even when it's 30 below outside, if the sun's shining, it'll be too warm for a fire," Stephanie said. "I burn about 1 cord of wood a year.

"The only back-up heat is in my bathroom ceilings. I have two radiant heating panels—one upstairs and one downstairs, but I don't use them very often—usually only when I leave for several days or more. Then I set the thermostat to operate the downstairs bathroom ceiling panel to keep the bathroom above freezing. My electric bill runs between $15 and $20 a month which includes everything—refrigerator, range, washer, dryer, the heating panels, and lights. And I use lots of lights during the winter."

At 5,700 feet elevation, cold winters are the norm for Virginia City, but that doesn't bother Stephanie Wood. She gets most of her space heat from the almost-daily sunshine coming through her large south-facing windows.

Not By Sun Alone

But there's more to harnessing free heat than just inviting the sun inside. It has to stay put. Thick insulation, double-glazed windows, concrete thermal storage, and over a mile of chinking trap heat in the 24-foot x 32-foot house. In the attic, fiberglass and Thermax insulation stop heat from drifting out the top of the house.

Each pine log, 10 to 12 inches in diameter, was carefully shaped with a chainsaw to fit down tightly on the one beneath. Sill Seal between logs and acrylic caulk chinking in the joints inside and out reduce infiltration. Stephanie noted it took her one full year to chink the logs, one of the jobs she'd delegate to someone else if she had it to do over.

A concrete floor in the front half of the living area soaks up heat from the sun and wood stove and releases it as the house cools. "The sunspace is actually part of my living area," Stephanie said. "It would be nice if it were separate, but I couldn't afford the extra square footage." An insulated rock bin beneath the concrete floor was constructed to provide more thermal storage. A wooden 1-foot x 2-foot "chimney" will run from the bin to the upper reaches of the large open living space. The plans call for a fan to pull hot air down from the ceiling through the box to the rock storage. A plenum and fan on the west side of the concrete floor will channel warm air back into the room.

At winter solstice the sun's rays creep 18 inches up the back of the living room wall, but overhangs on the front of the house keep the sun out during the summer. "The house overheats sometimes in fall and spring," Stephanie said. "Draperies would help that."

Under the back half of the living area, a walk-out basement provides space for washer and dryer, cross-country skis, saddles, and other necessities. Fiberglass batts were installed between the floor joists above the basement. One-inch extruded polystyrene was installed on the outside of the basement walls. The 6-inch

Owner
Stephanie Wood

Location
Virginia City

Designer
Owner

Builder
Pat Sandon and Bob Erhdall
103 West Jefferson
Virginia City, MT 59755
843-5352

Style
Log 2 Story

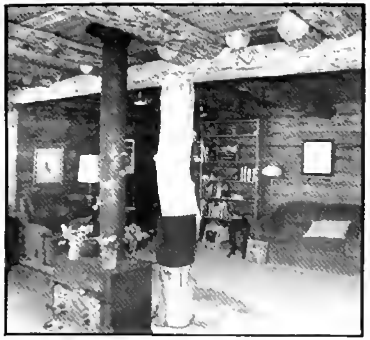
Insulation
Ceiling - R40
10- to 12-inch Log Walls - Approx. R8
Basement Wall - R5
Basement Slab - R5

Square Feet
Upper - 768
Main - 768

Special Features
Thermal Storage
Economical Construction

Heat
Passive Solar, Wood, Electric Panels

Completed
March 1984



Combining living space into one large room allows for good air circulation. A concrete floor stores heat from the sun and wood stove.

basement slab rests on a moisture barrier of 6-mil polyethylene over a layer of gravel. "I've never had anything freeze in the basement," Stephanie said.

If she were building again, Stephanie would do a few things differently. She would provide better ventilation for the downstairs and more heat for the upstairs, for example. Only two windows open on the main level—one in the bathroom and the other on the west of the living room. "I really need one on the east wall of the kitchen to get a good cross breeze," Stephanie said. "And I thought the upstairs would overheat in winter, but sometimes it's too chilly. Eventually I'll put a ceiling fan above the stairway to pull heat upstairs."

A Shoestring House Budget

Scrounging, salvaging, and buying used material enabled Stephanie to build the house. "It's amazing what can be done on a shoestring," she said with a laugh. "Every time I saw a bargain, I took advantage of it." She pointed out the windows. "All those are patio door blanks. The dealer wanted to get rid of them so I bought them at half-price two years before I started building. I bought all the logs peeled and delivered for $2,000."

Built to Leave

The house reflects more than tight-fisted cost control, however. It was built to take care of itself when its owner is away. Stephanie, a range technician with the U.S. Forest Service, is gone periodically. "When I built this place, I would literally stand here and wonder what problems could arise during my absence," she said. "I wanted to be able to leave and be gone for periods up to several months and not have to worry about a thing. One of the strategies I used was to put all the plumbing on the inside wall between the kitchen and bathroom to prevent any frozen pipes."

The house passed the test. "I was heading for New Zealand for a month one winter," Stephanie said, "I put the house plants in the bathroom, set the electric ceiling panels in that room for 50 degrees, and closed the door. My friend who looked after things checked the thermometers I had around the house. It never dropped below freezing in any part of the house although it got down to minus 30 outside. My electric bill for that period was $27."

Sunsets Balance Lightning Storms

Because her house is perched on a mountaintop overlooking Virginia City, Stephanie had to think of other natural elements besides cold and wind. A length of thick copper cable runs from rooftop to ground, fending off any effects from lightning strikes. "The storms get a bit close at times," she said, "but the view, the space, and the incredible sunsets are worth it. And, I'm totally sold on solar, and anyone who doesn't take advantage of it is crazy. I read books for two years before building, including the ones DNRC published on active and passive solar heating. That's where I learned to turn the house 7 degrees west of south for the best solar gain in this area." □

The house reflects the owner's liking for curved structures. A curving log staircase leads to the spacious bedroom and bath occupying the second floor. Crooked Douglas fir log uprights support the main beams. Outside, curved railings surround the deck wrapping the south and west sides of the house.

Heating a House in Snow Country for Less Than $100 A Year

West Yellowstone, as the nation knows, has winter, winter, and more winter. So it isn't exactly the town you'd think would be at the top of the list for a retirement choice. Common sense says if the cold doesn't get you, the heating bill will.

"On the contrary," said Bill Colman. "I use about two thousand kilowatt-hours annually to heat my house. At four cents per kilowatt-hour, that's less than a hundred dollars a year. And why do I live here? Look at the opportunities: cross-country skiing out the front door, snowmobiling in the Park (Yellowstone), hunting, and wildlife watching."

Recently retired from crop-dusting in the Fort Benton area, Bill moved to West Yellowstone a few years ago. His sturdy redwood-sided house stands among tall pines on the west side of town. Although the house came down the road 150 miles from Butte in two sections, it looks just like its "site-built" neighbors. A product of Buffalo Homes, the factory-built modular house has a full basement. "We dug the hole and put in the foundation before it got real cold. The house arrived in January," Bill reflected. After the two sections of the house were set onto the basement, they were joined at the center, and the staircases—half in the basement and half in the modular—were connected.

Heavy insulation in Bill Colman's modular house located in West Yellowstone keeps electric heating bills under $100 a year.

Owner
Bill Colman

Location
West Yellowstone

Designer
Owner and Buffalo Homes, Inc.

Builder
Buffalo Homes, Inc.
185 S. Parkmont Industrial Park
Butte, MT 59702
494-5550

Style
Split Entry

Insulation
Ceiling - R60
Double Wall - R41
Basement Wall - R30
Slab - R10

Square Feet
Main - 1,372
Basement - 1,372

Special Features
Modular Construction
Splayed Windows

Heat
Electric Baseboard

Completed
April 1985

Tight Seal Stops Heat Leaks

The house has a tough hide. Double 2 x 4 walls and raised-heel trusses filled with insulation serve to buffer the house from whatever the weather hands out. All exterior doors are tight-fitting insulated steel. Penetrations through the air-vapor barrier are kept to a minimum. For instance, there are no recessed lights and no stove chimney.

Having few windows and facing the house 17 degrees east of true south also help keep heat bills low. "I have one square window on the north side, over the sink, two tall, skinny windows in the dining room on the west, and a reasonably sized window on the east wall of my office; the rest face south. My aunt was visiting and complained that the bathroom lacked a window. I told her, 'just look at the electric bill and you'll feel better.' At night I turn the heat back 10 degrees. Even on chilly mornings, the sun will heat the house about as fast as turning up the heat.

"Contrary to what people might think, though, I am not living like a mole." Bill ran his hand over the deep windowsills framing the double-glazed low-E windows on the south side of the living room. "Notice how the window jambs are mitered at 45 degrees. It opens them up—similar to bay windows." The off-white vaulted ceilings and walls effectively diffuse the natural light.

Neither the split entry nor the side door near the dining room lent themselves to airlock vestibules, so Bill didn't try to fit them in. "Of course, there's only the cat and me. If you had four more pairs of boots clustered around that front door

and as many people running in and out, an airlock entry would probably pay for itself."

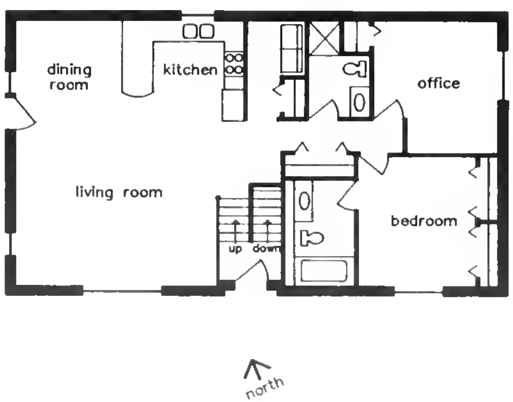
Double walls, an insulated slab, and south-facing garden windows all work to keep the basement at an even temperature. "I think I've had the heat on down here maybe twice. It stays about 60 to 65 degrees year around."

A heat recovery ventilator runs continuously on low. A preheater keeps it from icing up on really cold days. "I haven't shut it off since I moved in and I've had absolutely no trouble with it. It seems to keep the dust out of the house, too. That's pretty important to a guy who doesn't spend a lot of time with housekeeping chores."

Why electric heat when a forest of firewood surrounds him? "I don't mind looking at a fire, but fooling with it is something else. I know everyone around here burns wood. I just tell them, 'Sure would like to chop wood today, but I have to go snowmobiling."

But electricity doesn't come free. "We pay $15 a month for the privilege of having a line to our house. None of that goes towards kilowatts used. On top of that, our electricity costs us four cents per kilowatt-hour in the winter and eight cents in the summer."

Bill used 760 kilowatt-hours (kWh) in January and 750 in February. Usage dropped to 480 in March then 360 in April of 1987. "I haven't turned the heat on since April, so 360 kilowatt-hours at $9 is my average monthly use for lights and hot water from April to October. In the summer I close the windows during the day and open them at night to cool off. It stays quite comfortable year around."



Living in Snow Country

Bill has some advice for living in a cold and snowy clime such as West Yellowstone. The attic must be well ventilated to carry off the moisture. "A continuous ridge vent with continuous soffit vents is the best way," he emphasized. "Many builders feel that snow will blow into the ridge; but that just isn't so."

And the soffit vents have to be clear. "I had my heat exchanger exhaust at the side of the house just under the soffit. The outgoing moist air was freezing on contact with the soffit, plugging the vents 10 feet in both directions. As soon as I extended the exhaust to the edge of the roof, that stopped."

Designing a Modular House

Bill chose the Buffalo Home because it seemed to be the most cost-effective house for the climate. He said additional benefits have turned out to be its almost sound-proof interior and overall low maintenance.

"The basic floor plan was my idea. Buffalo Homes helped put it into a logical design for building. About the only thing I had to remember was to keep the two sections of the house narrow enough to carry down the highway, and to keep the plumbing on one side so it didn't cross from one section to another." ☐

Splayed window jambs open up the 13 1/2-inch-deep walls to admit more light. Octagon window and glazing in the front door (left) bring light into entry and basement.

Earth Berming, No Concrete

Earth-sheltered and underground houses are popular in eastern Montana, but the home of Ron and Mary Pipal outside Wolf Point is an earth-sheltered house with a difference. The main difference is the lack of concrete. Ron Pipal, a professional builder, said he doesn't particularly like concrete. Therefore, the 2,500 square foot, two-story earth-sheltered house he built for his family has no concrete in it or under it.

Instead of a concrete slab, the house sits on a 12-inch pad of gravel. Floor joists on the ground floor are 2 x 6s on 12-inch centers. These joists rest on 2 x 10s that lie flat on the surface of the gravel at right angles to the joists. The 2 x 10s are on 7 foot centers. Besides supporting the floor joists, the 2 x 10s provide a 1.5 inch space that allows the passage of air under the joists. In the winter, heated air from the Pipals' 96-percent-efficient Amana 120,000 Btu natural gas furnace is blown into the plenum under the floor, and is then vented back into the living space. (DNRC building specialists suggest that the energy efficiency of the under-floor plenum might be improved by insulating the bottom and sides to prevent the escape of heat.)

The Pipal house is a rare item: a two-story earth-sheltered house without an ounce of concrete.

Coolness of the Earth in Summer

In summer, cooling is provided by using the furnace fan to blow air from the living space into the plenum under the floor where it is cooled by the gravel before returning to the interior of the house. Another difference between the Pipal house and most other modern houses is the use of vapor-barrier paint rather than the commonly used polyethylene film air-vapor barrier. (DNRC building specialists note that an air-vapor barrier consisting of vapor-barrier paint is not continuous unless gaskets are used between the studs and the drywall to prevent the movement of air through small passages such as cracks where the drywall joins the floor. The use of vapor-barrier paint and gaskets behind the drywall to create an air-vapor barrier is called the Advanced Drywall Approach, or ADA.)

Pressure-treated Wood

Exterior walls are 2 x 6 studs on 12-inch centers, sheathed with 1/2-inch pressure-treated plywood. All wood below grade is pressure treated and the manufacturer guarantees it for 100 years if it is properly installed. For additional strength in the below-grade portion of the outside stud wall, every fourth stud was doubled. The Pipals have lived in the house since 1984, and no significant problems have been noted so far. The only caution about using stud walls in place of concrete below grade, Ron said, is that great care must be

Owners
Ron and Mary Pipal

Location
Wolf Point

Designer
Owners

Builder
Pipal Construction
P.O. Box 1148
Wolf Point, MT 59201
653-1464

Style
2 Story, Earth-bermed

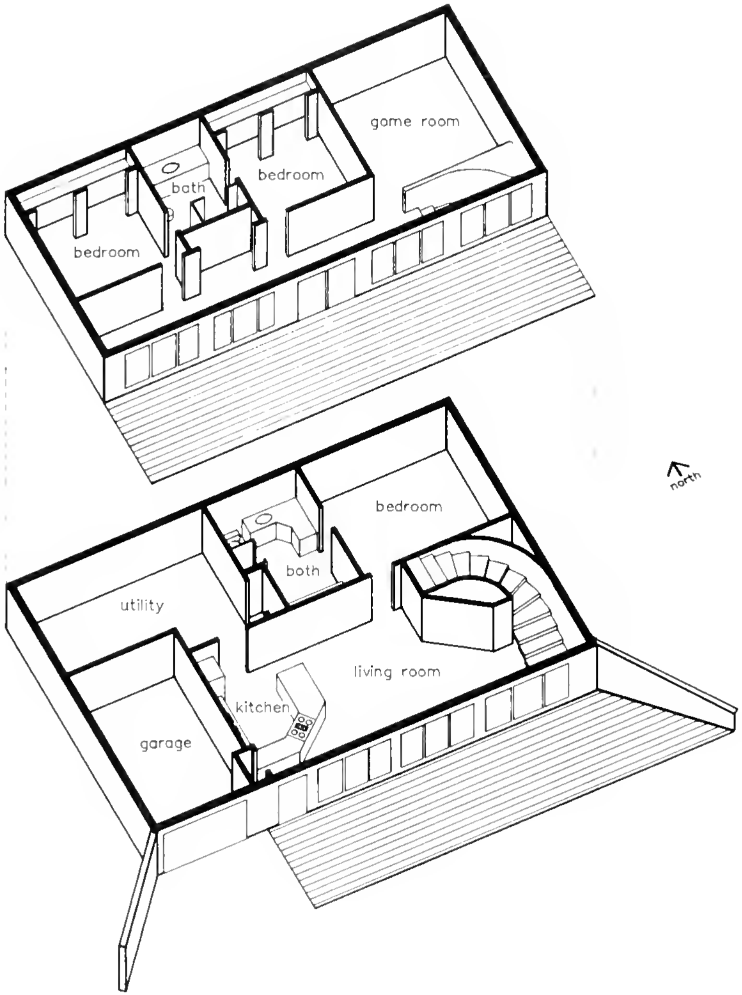
Insulation
Upstairs Ceiling - R44
Outside Walls - R19

Square Feet
Upper - 1,056
Main - 1,536

Special Features
No Concrete Used
Earth Berming
Under-floor Heat Plenum
Thermal Window Quilts

Heat
Passive Solar, Natural Gas

Completed
July 1984



taken in backfilling to avoid placing too much strain on the walls. "You've got to know what you're doing," he said.

Sun is There When Needed

The house faces due south to take maximum advantage of the sun. The roof overhang is designed to keep direct sunlight from entering on summer days when heat is not needed. The sun makes its welcome return to the inside of the house during the last part of October, and stays for about six months, Ron said. The direct sun that enters in winter warms the brown quarry tile floors both upstairs and down, and the floors then radiate heat long after the sun is gone each day. Ron said the house stays cool in the summer, and if the inside temperature rises above 70 degrees they can turn on the furnace fan and cool it off in a few minutes. The Pipals have never experienced a summer temperature above 78 degrees on the main floor of the house, even when outside temperatures reach 110 degrees.

Thermal Quilts Help Hold Heat

Thermal quilts on the upstairs windows help prevent heat loss through the glass, Ron said, adding that the quilts reduce heating requirements by about 20 percent on some winter days. The quilts in combination with the window glass have a rated insulating value of R6, Ron said. These quilts are made by Appropriate Technology, Inc., in Brattleboro, Vermont.

Insulation in the outside walls is R19 6-inch foil-backed fiberglass batts. The roof is insulated with 12 inches of cellulose to an R-value of 44. Two-inch extruded polystyrene boards were used to insulate below-grade across the front of the house, extending down 2 feet below floor level.

The combination of insulation and solar heating appears to be effective in keeping energy use down. Examination of the Pipal's bills for 1987 shows that 43.3 thousand cubic feet of natural gas were used to heat the house that year, bringing the year's total space-heating bill to $208.53. Gas consumption for heat was highest during January of that year, when the bill was $38.05. Ron said daily gas consumption stays below 0.30 thousand cubic feet per day (about $1.50 worth) when the house is held at a constant 70 degrees, even in the coldest weather.

Triple-pane Windows Another Good Idea

All windows in the house are triple pane. The operable windows are Weathershield casement type, with a home-made insulated wooden door to the outside. Ron said that materials for the house cost about $40,000. He did the work himself, so there was no substantial labor cost in the building. However, he said it would cost about $27 a square foot to hire a contractor to build a similar house, for a total of about $69,000. The appraised value of the Pipal house is $86,000.

No Underground Feeling

The interior of the house is bright and airy with no "underground" feeling. The banks of south-facing windows on both levels make the inside of the house brighter than most conventional houses. The light-brown quarry tile used on the floors of both levels contributes to the warm feeling. Ron said he and Mary

Plants thrive in the sunspace that extends the full length of the house's upper level. Note thermal quilts rolled at top of windows.

A graceful curving staircase connects the two levels in the Pipal house.

selected this particular tile because it felt warmer to the touch than others they looked at. It is made in Italy of volcanic ash and sold in Montana by Color Tile.

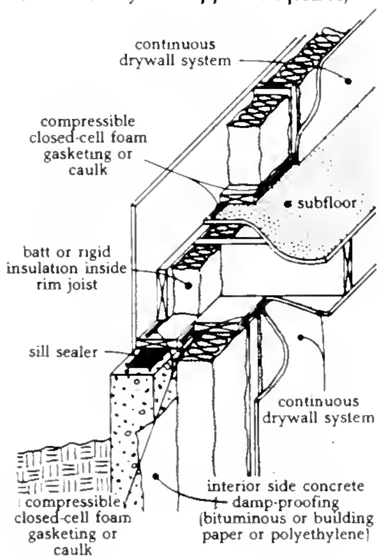
Ron said if he were building his house today, the only thing he would do differently would be to design it in a concave shape with the concavity facing south so it could collect sun over a longer period each day. The Pipals based the design of the house on plans in Earth Shelter magazine, and Ron said he welcomed the opportunity to try many ideas he had developed in his years of building. It all adds up to a comfortable house with a difference. ☐

Glossary

acoustical sealant: A non-hardening, gummy material that adheres well to polyethylene air-vapor barriers and plastic electrical boxes. It comes in a quart tube similar to caulking material. Many Montana builders are using the black acoustical sealant manufactured by Tremco. Tremco does not dry out, crack, or lose its adhesive abilities over time.

advanced drywall approach (ADA): A continuous air-vapor barrier consisting of compressed-foam gaskets or caulk used to seal critical joints between the drywall and the framing members, and vapor-retarder paint on or plastic sheeting under the drywall surface to keep warm, moist air inside the living space and out of wall and ceiling cavities.

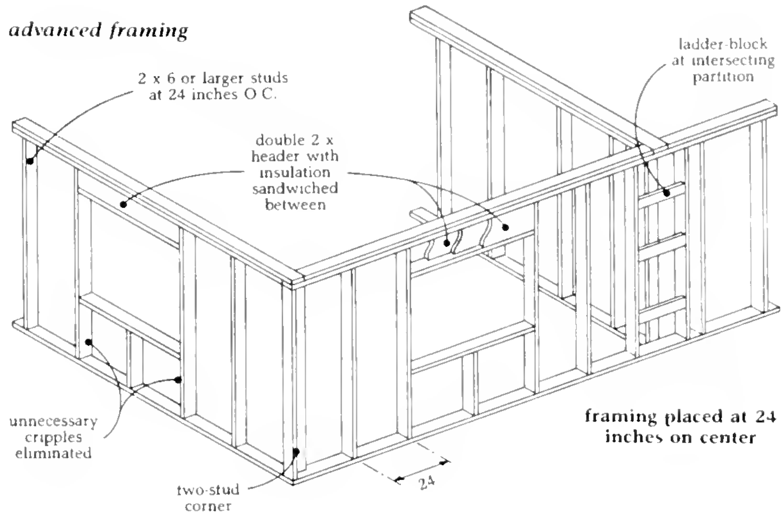
advanced drywall approach (ADA)



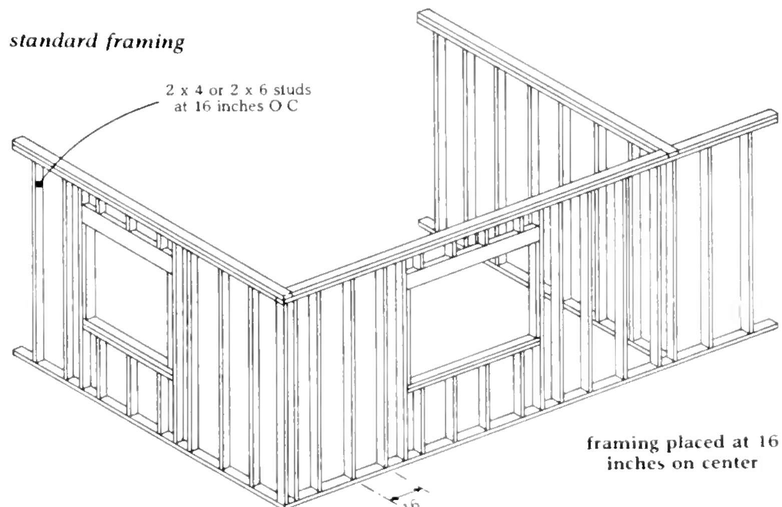
advanced framing, (also called Optimum Value Engineering, or OVE): Construction methods that reduce the amount of non-structural wood in a building. Eliminating these framing members decreases conductive heat loss through the wood, and increases the amount of insulation that can be placed in walls and ceilings. The term also refers to working in standard (4-foot x 8-foot) increments to reduce waste.

air barrier: A material or combination of materials used on the exterior of a building to block the flow of air while letting moisture vapor pass through to the outside. Materials commonly used in Montana are spun-bonded polyolefin such as Tyvek, and cross-laminated high-density polyethylene with tiny holes, such as Rufco-Wrap and TuTuf Air Seal. (See illustration under *double wall*.)

advanced framing



standard framing



air change per hour (ach): The number of times in an hour that enough outside air filters into a building to completely replace the interior air. In the winter, heat rides out with the displaced air; in the summer, cool air is usually the traveler.

air-vapor barrier: A material or combination of materials installed in ceilings and exterior walls to prevent passage of moisture and heated air from the living space. The air-vapor barrier must be located inward from the point in the wall where condensation otherwise would occur. The exact point depends on temperature and humidity inside and out, on R-values, and permeability of various materials in the wall. (See *dew point.*)

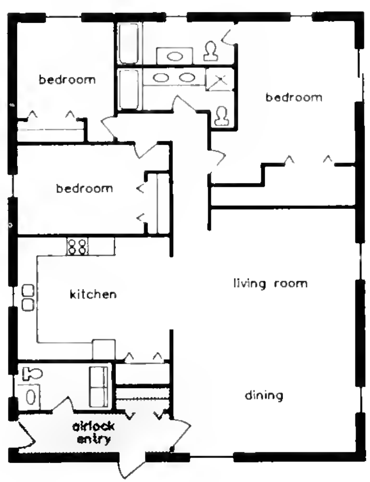
A handy rule of thumb is that one-third of the wall's R-value should be inward from the air-vapor barrier. This especially applies to double wall construction with three layers of fiberglass batt insulation. In this configuration, the only acceptable choices for placement of a polyethylene air-vapor barrier are under the drywall, or between the innermost and middle sections of insulation (about one-third from the warm side). In other types of insulation configurations, however, it is permissible for the dew point to fall at different spots and the one-third/two-thirds rule is oversimplistic. With a continuous layer of insulation such as urethane, for example, the location of the dew point will vary with the thickness of the insulation. Prospective home builders should contact DNRC or a qualified urethane installer to determine the appropriate air-vapor barrier placement in a specific situation.

The one-third/two-thirds rule does not work well for walls of R11 or less, because the lesser amount of insulation results in a cold wall where water may condense at any point, depending on indoor and outdoor temperatures and other contributing influences.

Polyethylene sheets from 4 to 10 mils thick commonly are used as an air-vapor barrier. (See *continuous air-vapor barrier* and the illustration under *double wall.*)

airlock: An enclosed entry with one door to the outside and one or more to the living space. The airlock entry limits the exchange of inside air and outside air when a person enters or exits.

airlock entry



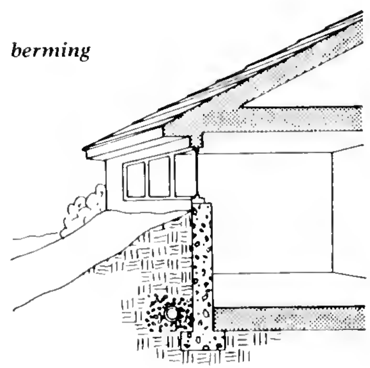
airtight drywall approach: See *advanced drywall approach.*

attic ventilation: Providing for the natural flow of air through the attic or roof of a building.

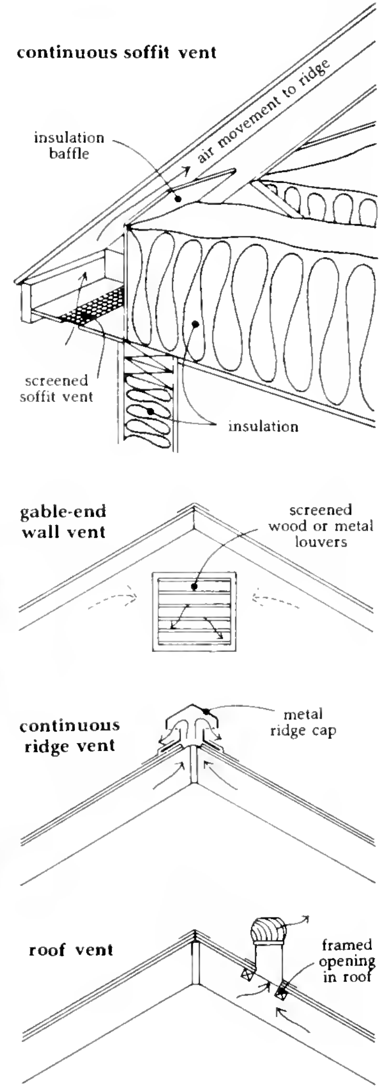
back drafting: The unintentional drawing of air into a house through chimneys, stove pipes, or furnace flues to replace the inside air removed by stoves, appliances or vents. As air is drawn through these openings, noxious gases and particulates of the combustion process ride along. The gases and particles can irritate the lungs, eyes, nose, and heart, and some, such as carbon monoxide, can cause death.

berming: Piling earth against one or more sides of a house. Berming protects the house against the extremes of hot and cold weather and wind.

berming



attic ventilation



BIBS: Abbreviation for blown-in-blankets. See *insulating materials.*

Bituthene: A plasticized asphalt product used primarily for waterproofing concrete. Commonly applied to the roofs of underground houses. Comes in a roll with plastic backing.

blower door test: Use of a door- or window-mounted variable high-speed fan to blow air into or out of a house to simulate the effects of pressure changes that cause air infiltration or exfiltration to occur. By simulating the different pressure changes, the overall air change rate of the house can be calculated with the aid of a computer program.

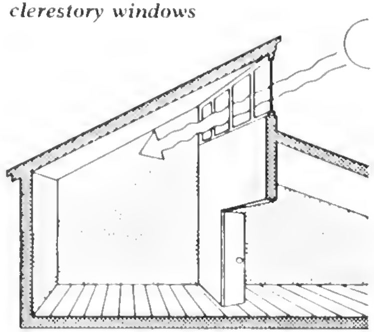
The test also aids in finding air leaks around windows, doors, baseboards, wall and ceiling joints, wall and floor joints, plumbing openings, and electrical boxes. (See *infiltration.*)

Btu: Stands for "British thermal unit," and represents the amount of heat needed to raise the temperature of 1 pound of water by 1 degree F. One Btu is about equal to the heat given off by one kitchen match. Heat requirements of houses and the amount of heat derived from various heating systems commonly are expressed in Btus.

clerestory: A vertical wall incorporated into a roof, and containing windows.

combustion air: The air needed by stoves and furnaces for the combustion process. (See *sealed combustion.*)

clerestory windows

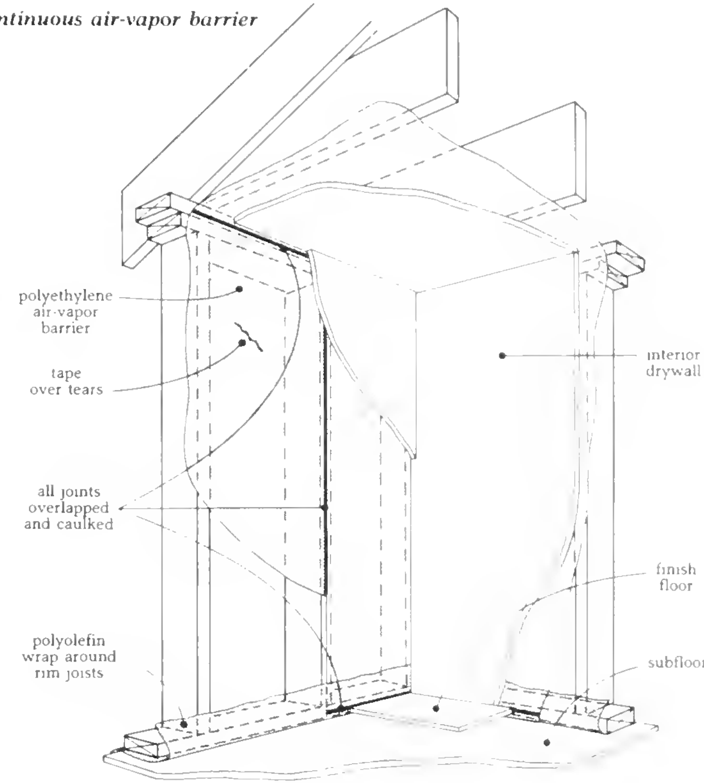


conductive heat loss: Movement of heat through a solid material, such as heat moving from a house's warm interior through studs to the outside. (See illustration under *thermal bridging.*)

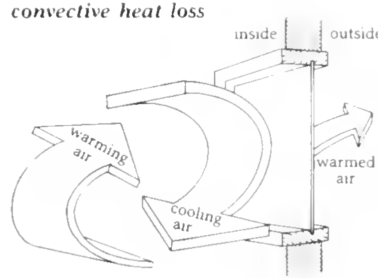
continuous air-vapor barrier: An impermeable membrane or surface enclosing all portions of the living space. An alternative is the noncontinuous air-vapor barrier. For example, some houses have an air-vapor barrier in the walls but not in the ceiling. In other cases, the barrier is left unsealed at seams or joints. Read the "Introduction" section for cautions on non-continuous air-vapor barriers.

convective heat loss: Refers to the movement of heat through a fluid such as air or water. For example, the loss of heat that results when a cold window pane cools air in a room, causing the cooled air to sink and warm air to rise to replace it, and be cooled in turn. Or when wind blows against a warm window carrying heat away from the glass surface.

continuous air-vapor barrier



convective heat loss



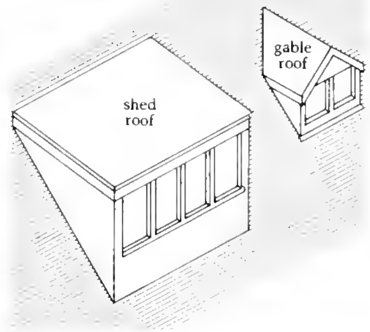
DNRC: The Montana Department of Natural Resources and Conservation. As the name implies, DNRC is concerned with the wise use of natural resources, including energy. The saving of energy through construction of energy-efficient houses is a major department priority.

dew point: The temperature at which water vapor in the air changes to liquid. As air cools, it loses its capacity to hold water vapor.

direct vent: See *sealed combustion.*

dormer: A framed structure projecting from a sloped roof, normally containing one or more vertical windows.

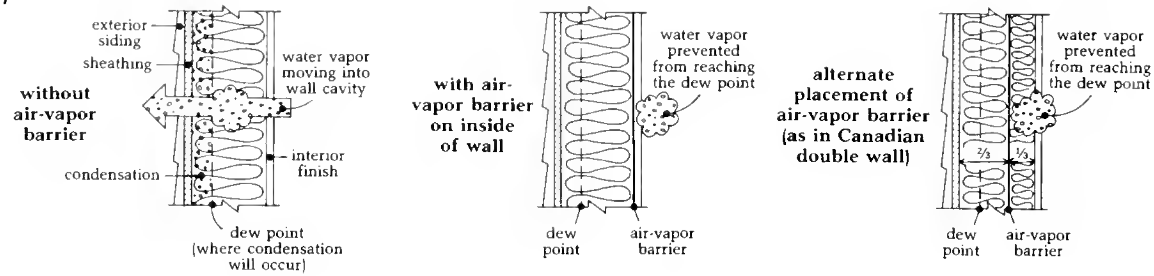
dormers



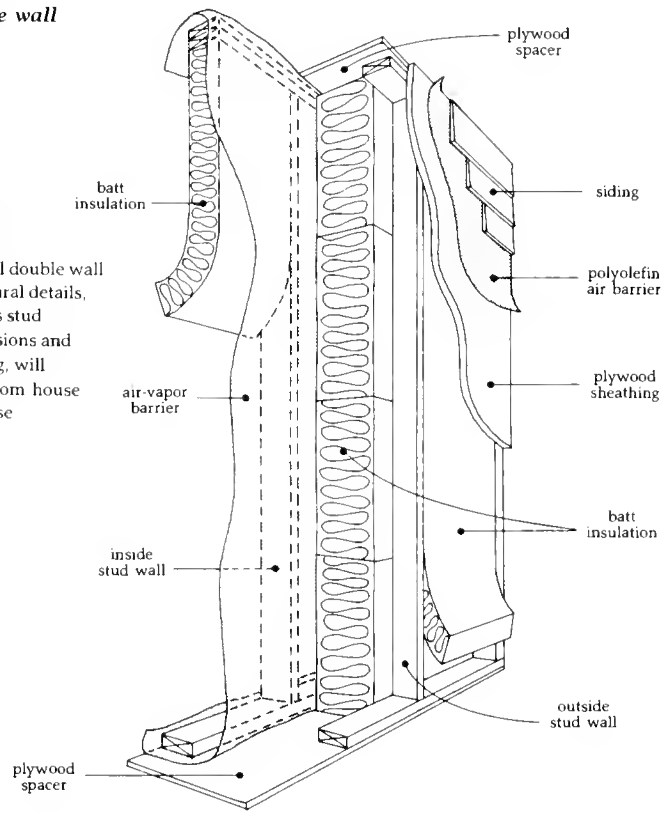
double-wall: An exterior wall comprising two stud walls, often with space between, which provides room for more insulation than possible in a single wall.

drywall: The finish portion of the interior side of walls, usually consisting of gypsum board, taping, and textured surface. May also be used to refer to gypsum board, wallboard, plasterboard, or Sheetrock.

dew point



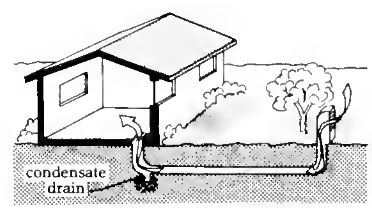
double wall



NOTE:
Typical double wall
Structural details, such as stud dimensions and spacing, will vary from house to house

earth tube: A tube buried below the frostline, usually 4 to 6 inches in diameter and often plastic, that brings outside make-up air into a house. The earth warms or cools the air, to what temperature depends on the length of the tube, outside air temperature, and soil temperature. Air enters the tube through a screened gooseneck rising above the ground surface. The horizontal portion of the tube is buried from 4 to 8 feet deep, depending on how deep the frost normally penetrates.

earth tube



envelope house: Envelope construction includes a double wall on the north side of the house and a double ceiling, with space inside the walls and ceiling for air movement. East and west walls are not designed with space for air passage. Envelope houses are usually two story, with sunspaces occupying the entire front of the house on both levels. Single-pane windows and a standard interior stud wall separate the sunspaces from the living space. A portion of the sunspace floor is made of 2 x 6 boards spaced an inch apart to allow air passage. Exterior windows are double or triple glazed.

The sunspaces are central to the envelope concept. Theoretically, air warmed by the sun in the sunspaces rises to the ceiling and enters the space left for it in the double ceiling, moves down to the north wall and descends through the hollow wall into the crawl space, and back up to the sunspace. In the summer, vents at the top of the sunspace allow hot air to escape, while ground-level vents on the north side of the house admit cool air to replace the escaping hot air.

Research has shown that the envelope principle does not always function as proponents would like to believe it does. The envelope house is energy efficient due to solar design features and a well insulated building shell. Most builders and other authorities agree that envelope houses are less cost-effective than superinsulated houses.

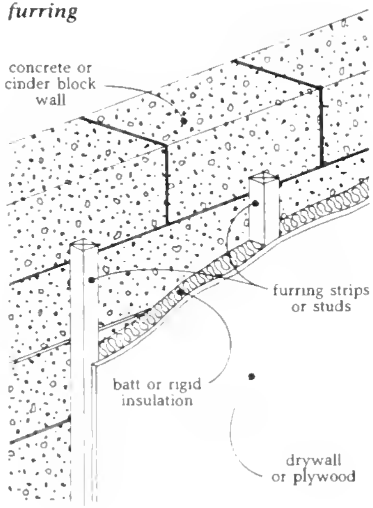
European cabinets: Cabinets made of high-gloss man-made laminate materials such as Formica, often with wood trim, and without protruding door or drawer knobs or pulls.

extruded polystyrene rigid foam board: Insulating material manufactured by an extrusion process usually incorporating Freon gas. Greater R-value and strength, and lower water vapor permeability and absorption set extruded polystyrene apart from expanded polystyrene. Board usually comes in 2 x 8 or 4 x 8 sizes. Manufacturers and their trade names and colors for extruded polystyrene include Dow—Styrofoam (blue); UC Industries—Foamular (pink); Amoco—Amofoam (green); and DiversiFoam—CertiFoam (yellow). Extruded polystyrene comes in varying densities and strengths.

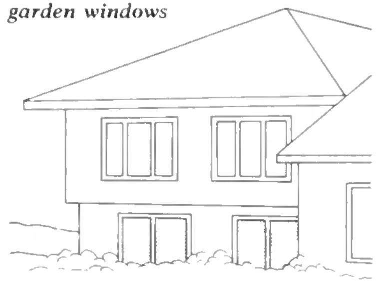
furring: Strips of wood used to create a space for insulation and a nailing base for another surface.

garden windows: Windows in a room partially embedded in the ground.

furring



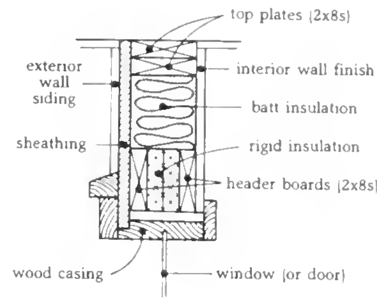
garden windows



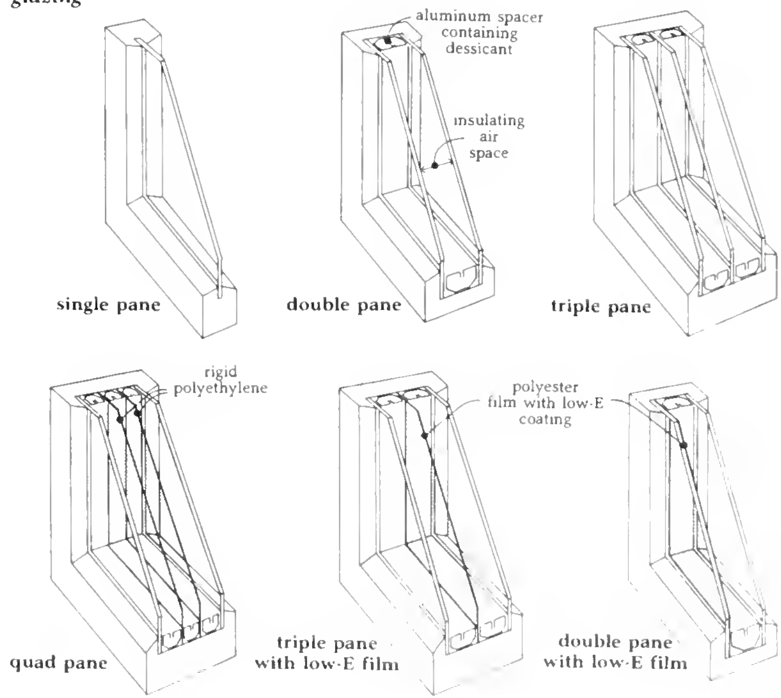
glazing: The transparent material used in windows, usually glass, but also can be polyester film, fiberglass, acrylic, and other materials.

header, insulated: The structural member placed over a window or door consisting of two wooden boards with rigid foam board between them.

insulated header

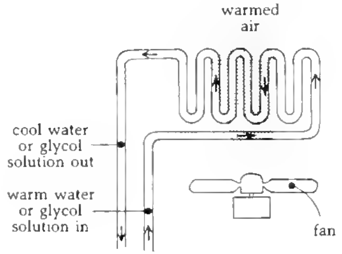


glazing



heat exchanger: A device for transferring heat from one medium to another. It commonly includes an array of tubes or fins that presents a large surface to exchange heat between the air, water, or other medium flowing through or past it.

heat exchanger



heat pump: Heating systems that use a refrigeration cycle to extract heat from air, water, or the ground. A circulating refrigerant liquid that is colder than the heat source absorbs heat and changes to a vapor. The vapor is compressed, which raises its temperature. The hot vapor travels through another coil where it gives up its heat to indoor air or water, and changes to liquid. The cooled refrigerant liquid passes through an expansion device that depressurizes it and causes it to cool to the point where it's ready to absorb heat again. Except at very low outdoor temperatures, less electrical energy is needed to extract heat from air, water, or ground using the refrigerant cycle than would be needed to directly convert electricity to heat, as in an electric furnace or baseboard heaters. The initial cost of the heat pump is considerably higher than that of a furnace, baseboard heaters, or ceiling panels.

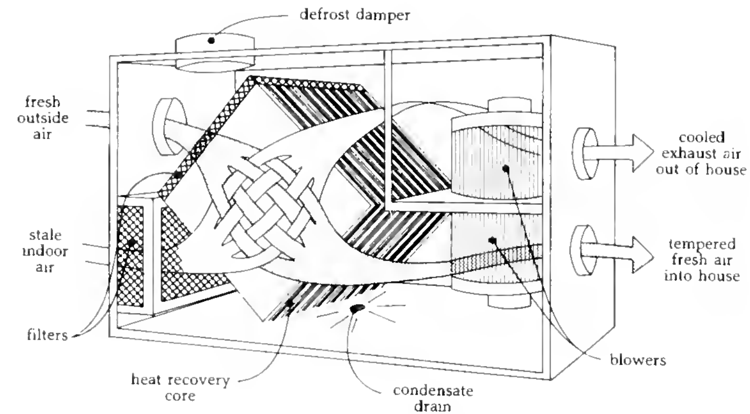
heat recovery ventilator (HRV), (also known as air-to-air heat exchanger, or AAHX): In tightly built houses, this device exhausts stale warm air and replaces it with outside air. The system includes a heat exchanger core to transfer a portion of the heat from the stale air to the colder incoming air. Some units are equipped with a duct heater between the HRV and the house to further warm the incoming air, and some are equipped with a duct heater between the HRV and the air intake to prevent freezing of the HRV in cold weather. In some cases, the intake air is warmed or cooled (depending on the outside temperature) by drawing it through a buried pipe. (See *earth tube.)*

HUD standards: Construction standards established by the U.S. Department of Housing and Urban Development. As applied in Montana, the standards require insulation values of R19 in walls and R38 in ceilings, and U values of 0.47 in windows and 0.083 in exterior doors. Generally, this requires 2 x 6 walls, room for 10 to 11 inches of insulation in the ceiling, double-glazed windows, and R12 insulated doors.

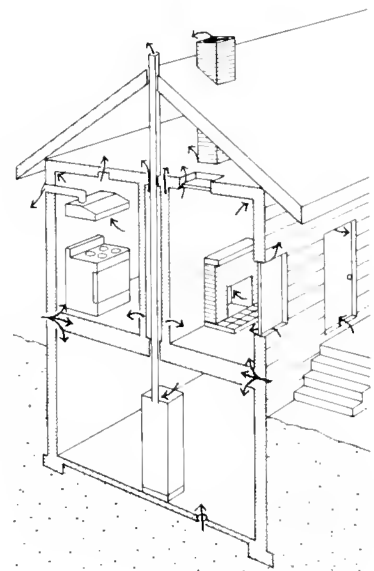
humidity: See *relative humidity.*

infiltration/exfiltration: Leakage of outside air into and inside air out of a house. Amount of infiltration and exfiltration depends on the size and location of cracks and other openings, wind speeds, and the temperature difference between inside and outside.

heat recovery ventilator



infiltration and exfiltration



insulating materials:

Cellulose is ground-up paper treated with chemicals. The chemicals include fire retardants, corrosion inhibitors, and, in the case of spray-on insulation, adhesives and wetting agents. Cellulose-based insulation comes as loose-fill or spray.

Mineral fiber includes two common varieties: fiberglass and rock wool, also called slag wool. Comes as batts, blankets, and loose fill. Loose-fill also can be wet-sprayed with an adhesive to take form as blown-in-blankets (BIBS) or blown-in-batts.

Perlite is a light, cellular substance in pellet form, made from volcanic material and comes as loose-fill.

Rigid foam board: See *extruded polystyrene* and *polyisocyanurate.*

Urethane foam refers to a family of compounds. Each foam uses a specific recipe to give it the characteristics desired

for a particular job. Foam is sprayed in layers to the desired thickness. Also acts as an air-vapor barrier.

Vermiculite is expanded, lightweight pellets made from silicate that are used loose or mixed in concrete and plaster.

insulation applications: The most common insulation applications are shown in the following illustrations.

insulation baffles: A barrier to prevent attic insulation from interfering with attic ventilation. (See illustration under *attic ventilation*.)

insulation configurations and application methods:

Batts are flexible strips of fibrous insulation in precut lengths, sized to fit between framing members; can be unfaced or faced with foil or Kraft paper.

Blankets is a form of insulation similar to batts, but in long rolls rather than short strips.

Foamed-in-place is a liquid mixture of urethane compounds sprayed onto open cavities or framing members (such as rim joists) in new or existing construction.

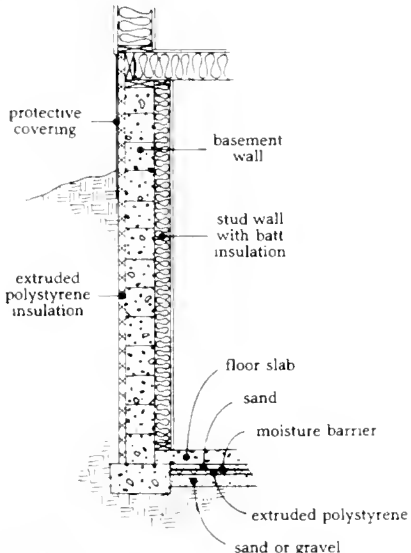
Loose-fill is insulation provided in loose, bulk form. It usually comes in bags and is poured or blown into attics and existing closed walls.

Rigid board: See *extruded polystyrene* and *polyisocyanurate*.

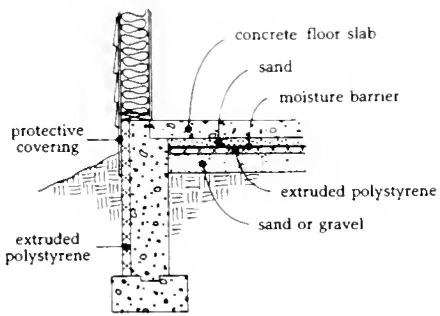
Wet-spray is insulation mixed with adhesive binder and applied under pressure from a "gun" to fill open wall cavities or attics. Netting attached to studs contains the material in wall cavities. (See "mineral fiber" under *insulating materials*.)

insulation applications

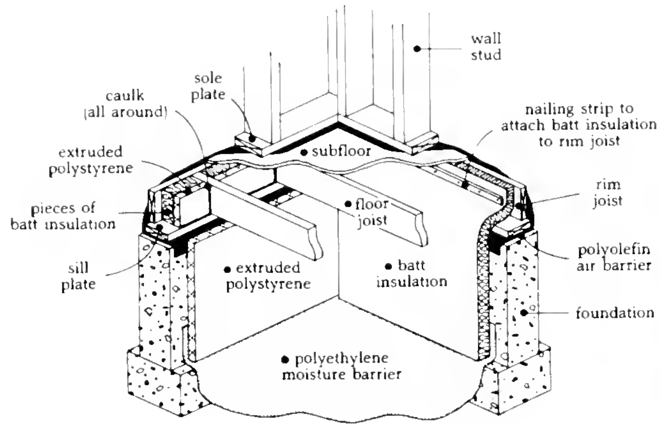
basement wall insulation



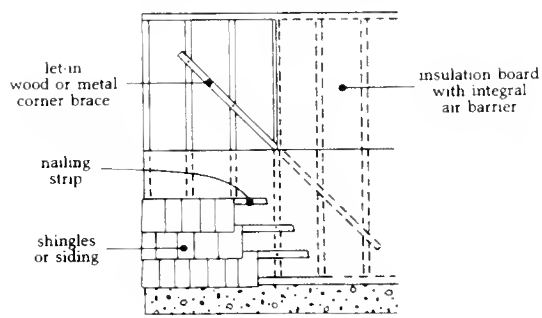
slab-on-grade insulation



crawl space insulation



rigid insulation used as sheathing



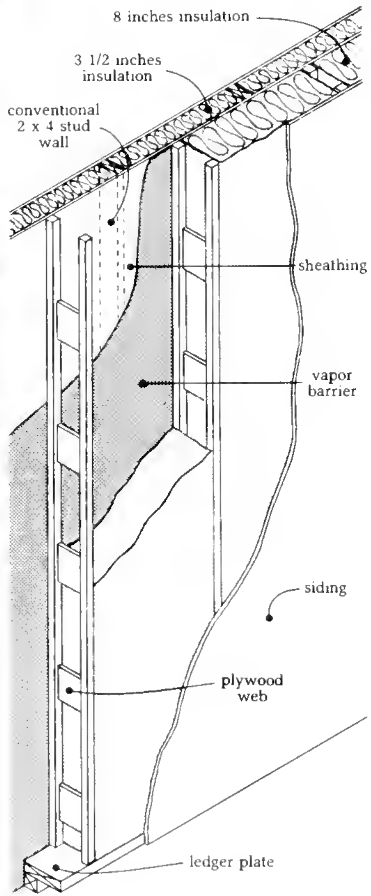
foamed-in-place insulation

wet-spray insulation

kilowatt-hour (kWh): The amount of energy equal to 1 kilowatt (1,000 watts) of power being used for one hour.

Larsen trusses: Trusses made with 2 x 2 chords and intermittent plywood webs. These trusses are nailed vertically to the outside of a conventional stud wall, usually on 24-inch centers. The trusses can be nailed either to the studs or to horizontal blocking between the studs. Normally the trusses are 8.25 inches deep, and can be insulated with any type of insulation. Horizontal or diagonal siding can be applied directly to the trusses, or sheathing can be applied and then siding over that.

Larsen truss



low-E: Abbreviation for low-emissivity film, thin layers of metals used to coat window panes. The coating admits incoming sunlight and some heat but stops radiant heat from escaping through the window. (See illustration under *glazing.*)

mil: A unit of measure equal to one-thousandth of an inch, commonly used in measuring the thickness of polyethylene.

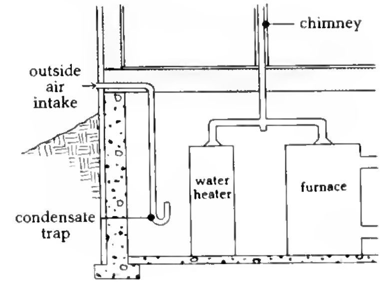
Model Conservation Standards (MCS): Standards proposed by the Northwest Power Planning Council for new, electrically heated residential and commercial buildings. To conform to the standards, buildings must be constructed so their electric heating budget doesn't exceed a certain number of kilowatts. In Montana the proposed budget for a single-family dwelling is 3.2 kilowatt-hours per square foot per year. For example, a 1500-square-foot house would have to be constructed so that its projected heating load would be less than 4,800 kilowatt-hours per year ($216 at 4 1/2 cents per kWh).

Optimum Value Engineering (OVE): See *advanced framing.*

oriented strand board (OSB): Board stock made from compressed strand-like wood particles arranged in layers and bonded with phenolic resin. Designed and manufactured for wall and roof sheathing and subflooring, the sheets are usually 4 feet by 8 feet.

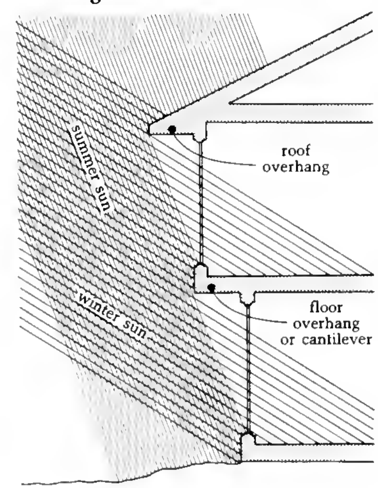
outside air intake: A duct or pipe that brings air from outside to support combustion in stoves, furnaces, or other types of burners. The air can be delivered to a room or directly to an appliance. (See *sealed combustion.*)

outside air intake



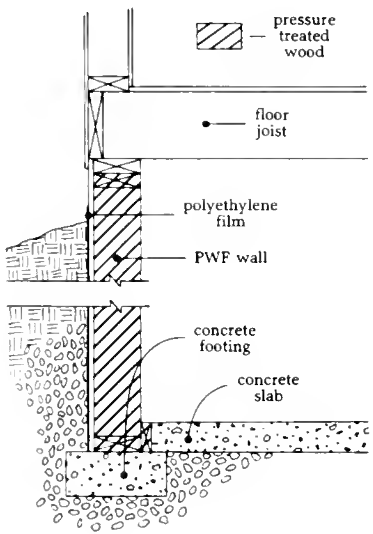
overhang: A part of a roof, floor, or deck that extends outward from a wall. Often used to shade windows from summer sun.

overhang



permanent-wood foundation, (also called all weather wood foundation, or AWWF): A building foundation made of wood, pressure-injected with preservatives, used in place of concrete.

permanent wood foundation (PWF)

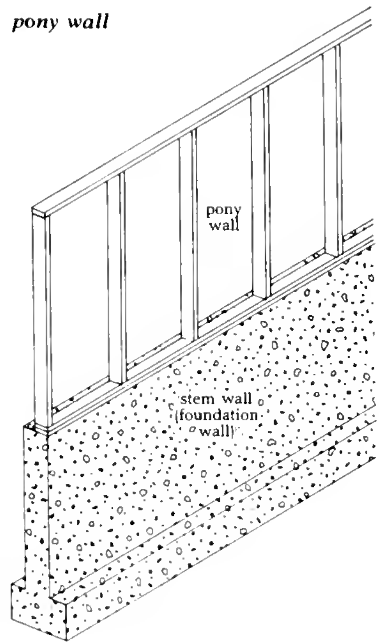


plenum: A passageway that conducts warm or cool air in a house. One example is ductwork from a furnace to rooms throughout the house. Another example is a cavity between studs in a wall used to disperse heated air from a solar collector into a room.

polyisocyanurate foam board: Sheets of a urethane compound usually used for sheathing the outside walls of a house. It normally is faced with foil on both sides. Polyisocyanurate has a high R-value and low combustibility compared to other urethane compounds. Trade names include Thermax, Energy Shield, and High-R Sheathing.

pony wall: A short frame wall used to support portions of the structure, often used in split-level houses.

pony wall



R-value: Refers to a material's ability to resist heat from passing through it by conduction. The higher the R-value, the greater the resistance to heat loss. A 6-inch fiberglass batt has an R-value of 19. A double-glazed window has an R-value of 1.8. This is the inverse of the U-value.

radiant heat loss: Heat movement from a warm object to a cooler object such as from a hot stove to a person standing near it.

relative humidity: The percentage of water vapor in the air relative to what it can hold. Excessive humidity can cause moisture to condense on windows. Very low humidity dries out the skin. Humidity between 30 and 40 percent seems to be the most common setting for dehumidistats on heat recovery ventilators in Montana.

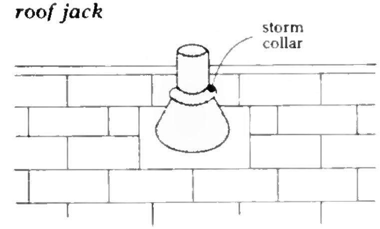
Residential Construction Demonstration Project (RCDP): A research and demonstration program instituted in 1986 to encourage construction of houses to meet Model Conservation Standards proposed by the Northwest Power Planning Council, and to incorporate at least one innovative energy feature. Some of the energy features are a heat recovery ventilator with duct heater, a heat recovery ventilator integrated into an electric furnace, an exhaust air heat pump, and an air-vapor barrier using the advanced drywall approach. Financial incentives covered the incremental cost of these innovations. DNRC is monitoring the houses to determine space heating costs, and performance of innovative energy features.

Residential Standards Demonstration Program (RSDP): A research and demonstration program instituted in 1984 to encourage construction of houses that meet or surpass Model Conservation Standards. Incentives helped defray increased costs for building components that are more energy efficient than similar components in HUD houses. Extra insulation, air-vapor barriers, and ventilation systems are some of these components. DNRC collected electrical use data between April 1985 and April 1986 to evaluate the energy efficiency of these houses compared to houses built to less efficient HUD standards.

rim joists, also called band joists or header joists: The joist that sits on the sill and extends around the perimeter of the house. (See the illustration under *insulation methods.*)

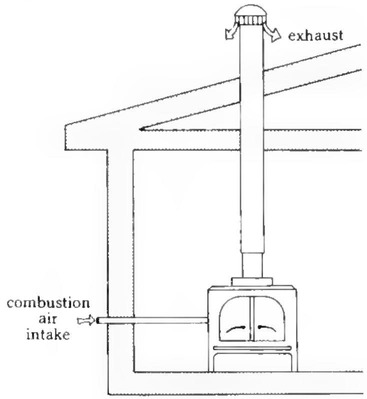
roof jack: A cone-shaped, flat-based flashing to seal the area where a vent, pipe, or duct penetrates the roof.

roof jack

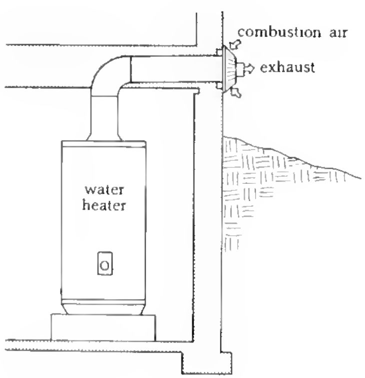


sealed combustion: A system in which combustion air is piped directly from outside into a stove or furnace so no house air is used. Sometimes also known as "direct vent," especially when referring to a double-walled vent that draws outside air in through one passage, and exhausts combustion gases through another passage.

sealed combustion

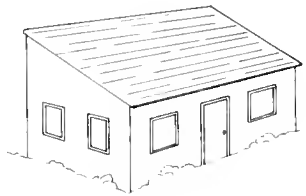


sealed combustion (direct vent)



shed roof: A roof with a single sloping surface.

shed roof



single wall: A wall built with a single row of studs; 2 x 4, 2 x 6, and 2 x 8 studs are commonly used to frame a single wall. (See illustrations under *thermal bridging*.)

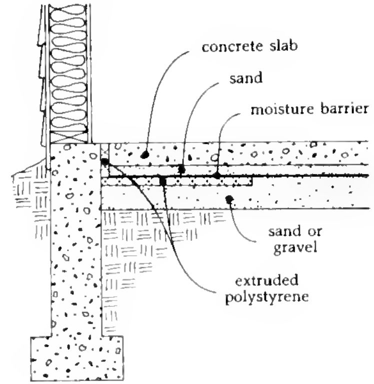
slab perimeter insulation: Rigid insulation installed under the outer portion of a slab usually extending from the foundation on the slab edge back under the slab from 2 to 4 feet.

soffit: The underside of a part of a building such as the eave. A decorative, boxed-in structure such as that over kitchen cabinets. (See illustration under *attic ventilation*.)

solar gain: Warmth gained from sunlight. Passive systems have no moving parts and commonly make use of a solar space or extensive south-facing windows to bring solar heat into the living space. These systems often use masonry as a storage medium for solar heat. (See illustration under *sunspace*.)

Active solar gain depends on mechanical devices such as liquid-filled collectors to absorb solar warmth, and extensive plumbing systems to transmit it to the living spaces. For example, fans that distribute the hot air in a rooftop solar collector to the rest of the house, or pumps that circulate the fluid from a rooftop solar collector through pipes in the floor are actively distributing the solar energy.

slab perimeter insulation



splayed window: A beveled wall on the inside of a window opening. Viewed from the inside, the window opening gives the illusion of a bay window.

spun-bonded polyolefin: An air barrier, such as Tyvek, made of thin polyethylene fibers bonded into a mat that stops air movement but allows moisture to pass through.

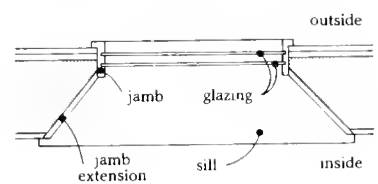
staggered stud wall: One of several stud placement configurations to avoid conductive heat loss through an exterior stud wall. (See illustration under *thermal bridging*.)

stem wall: The foundation wall, used particularly to describe the concrete portion of a frame-and-concrete foundation wall. (See the illustration under *pony wall*.)

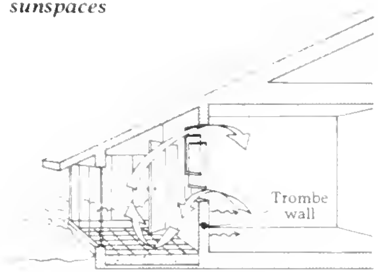
sunspace: A room on the south side of a house that acts as a solar collector, with glazing, thermal storage, insulation, and shading incorporated specifically for solar heat gain.

Super Good Cents: An electric utility-sponsored marketing program instituted in 1985 to encourage construction of houses to meet Model Conservation Standards. The Super Good Cents Home Award shows exactly what the builder has done to qualify the house for this distinction, and guarantees that the work has been certified by a utility representative.

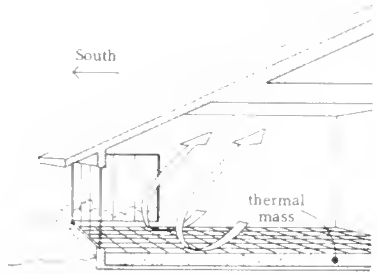
splayed window TOP VIEW



sunspaces



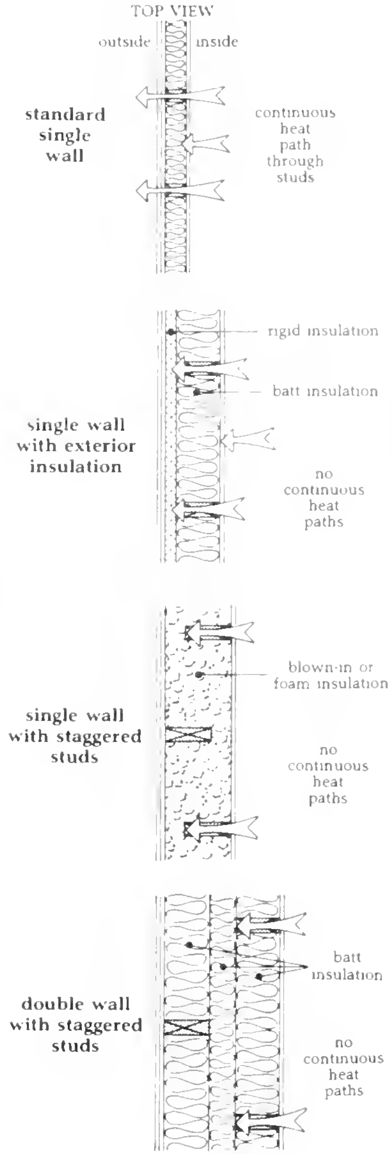
attached sunspace — circulation of air through wall openings and radiation of heat from Trombe wall, warms adjacent rooms indirectly



integral sunspace — living space is heated through direct solar gain and convection

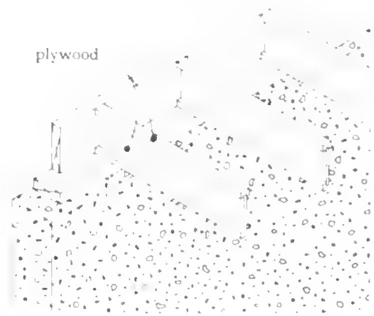
thermal bridging: Heat loss by conduction, such as heat moving from indoors to outside through wall studs.

thermal bridging



TJI joists: Truss Joist I-beams. Wooden I-beams of various depths, built with plywood and used as roof trusses or floor joists.

truss joist I-beam (TJI)



Trombe wall: A floor-to-ceiling masonry wall, set behind south-facing windows. The wall absorbs heat during the day and radiates it to the living space at night. Openings in the wall allow some of the heated air to circulate to the living space during the day. The openings are closed at night. (See illustration under *sunspace*.)

truss: A structural unit that spans long distances, used for roof support.

U-value: Refers to a material's ability to transmit heat by conduction. The lower the U-value, the less heat transferred. A 6-inch-thick fiberglass batt has a U-value of 0.0526. A double-glazed window has a U-value of 0.5555. This is the inverse of the R-value.

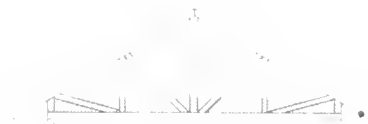
trusses

conventional truss

insulation is compressed above wall plates

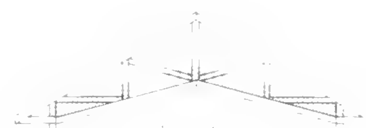
oversized truss

full depth of insulation covers wall plates



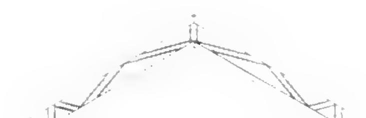
raised heel truss

rake tail soffit



scissors truss

ceiling slope is less than roof slope



parallel chord truss

for cathedral ceilings

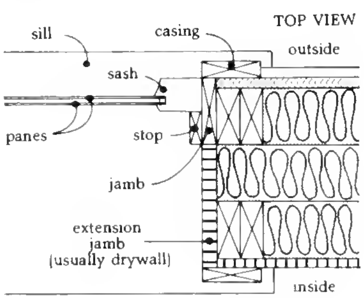
vapor-barrier paint: Paint with a very low moisture permeability used on drywall as a vapor barrier.

waferboard: Made of compressed wafer-like wood flakes bonded with phenolic resin. The flakes may be randomly or directionally oriented, and may also be arranged in layers. Designed and manufactured for wall and roof sheathing and subflooring, the sheets are usually 4 feet by 8 feet.

window coverings, insulated: Used to decrease heat loss at night by preventing warm room air from reaching window glazing. Names of some commercial window coverings are Window Quilt and Wonderful Window (also known as Warm Window).

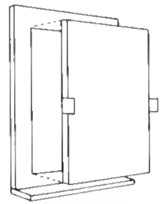
window jamb, extended: In double-wall construction, the piece that extends from the normal 2 x 4 framing on the side of a window enclosure to the interior wall.

extended window jamb

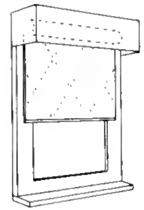


window types: The most common window types are shown in the following illustrations.

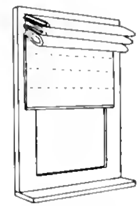
window coverings



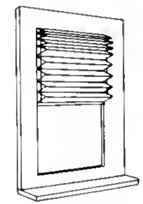
pop-in panels of rigid insulation are usually held in place by friction fit or magnets



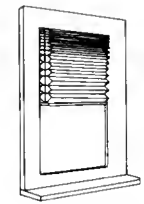
quilted roller shades usually have a valance to prevent air movement over the top of the roller



quilted roman shades can provide an R value of 7 if the edges are tightly sealed

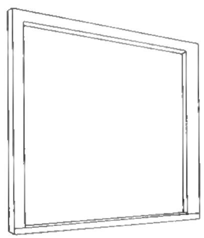


reflective accordian shades can reflect heat in or out but have little or no insulating value

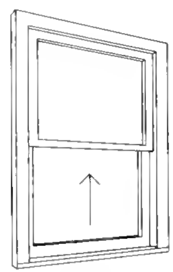


dual-pleated shades have a hollow structure which traps air and acts as an insulator

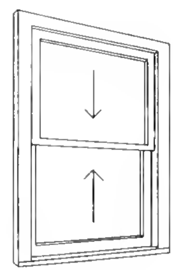
window types



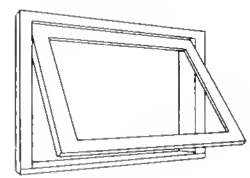
fixed



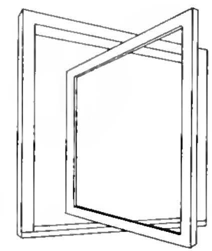
single hung



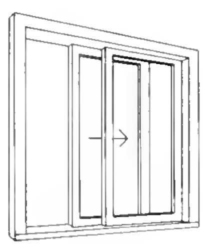
double hung



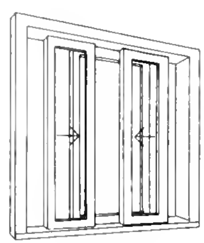
awning



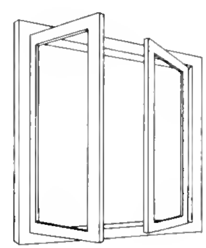
pivoting



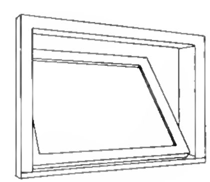
sliding



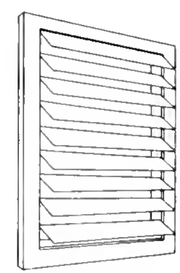
combination



casement



hopper



jalousie

For More Energy Information

The Energy Division of the Department of Natural Resources and Conservation has more than 80 free publications describing energy-saving techniques that work in Montana. Topics include new house construction, fortifying existing houses against the weather, choosing and operating a heating system, and window insulation. To order the publications or a catalogue describing them, write or call the Energy Division, DNRC, 1520 East Sixth Avenue, Helena, Montana 59620, (444-6697) or visit the Energy Information Center at your local post office or courthouse. The centers consist of literature racks containing energy publications. DNRC and the local County Extension Offices have a list of center locations.

Periodicals

Several periodicals that regularly carry articles about energy-efficient construction are listed here.

Custom Builder. PO Box 985, Farmingdale, NY 11737.

Energy Design Update. Cahners Publishing Company, PO Box 716, Back Bay Annex, Boston, MA 92117.

Fine Homebuilding. The Taunton Press, PO Box 355, Newtown, CT 96470.

Habitat. 200000. PO Box 4885, Edmonton, Alberta, CA T6E 5G7.

New England Builder. Builderburg Group, Inc., PO Box 278, Montpelier, VT 95602.

Practical Homeowner. Rodale Press, Emmaus, PA.

Other Suggested Reading

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